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RESISTANCE SCALING AND PREDICTIONS OF SLICE HULLS FROM MODEL TESTS

by

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September 1995

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This thesis evaluates several techniques for extrapolating full scale resistance of SLICE hulls from model test data. Using Froude's hypothesis, the ITTC and Hughes methods are employed to analyze single length and fragmented wetted surface area procedures. Finally, a hybrid procedure analyzing the struts as wing shapes and the pods as full hull forms is endeavored. It is shown that the classical Froude method severely overestimates the resistance of a SLICE hull. All approaches predict higher total resistances than Lockheed's own analysis, which is based on a variation of Hughes method. This thesis predicts that speeds of greater than thirty knots are achievable with the primary engine choice.

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RESISTANCE SCALING AND PREDICTIONS OF SLICE HULLS FROM MODEL TESTS

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Submitted in partial fulfillment
of the requirements for the degree of

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ABSTRACT

This thesis evaluates several techniques for extrapolating full scale resistance of SLICE hulls from model test data. Using Froude's hypothesis, the ITTC and Hughes methods are employed to analyze single length and fragmented wetted surface area procedures. Finally, a hybrid procedure analyzing the struts as wing shapes and the pods as full hull forms is endeavored. It is shown that the classical Froude method severely overestimates the resistance of a SLICE hull. All approaches predict higher total resistances than Lockheed's own analysis, which is based on a variation of Hughes method. This thesis predicts that speeds of greater than thirty knots are achievable with the primary engine choice.

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I. INTRODUCTION

In the development of new vehicles, resistance minimization is a primary design focus since the propelling force must match this drag. In general, less resistance permits higher speeds and decreases fuel consumption for the same propulsion plant. Surface ships are exposed to two mediums: air and water. This thesis focuses on the subsurface resistances of the SLICE ATD (Advanced Technology Demonstration), shown in Figure 1.1.

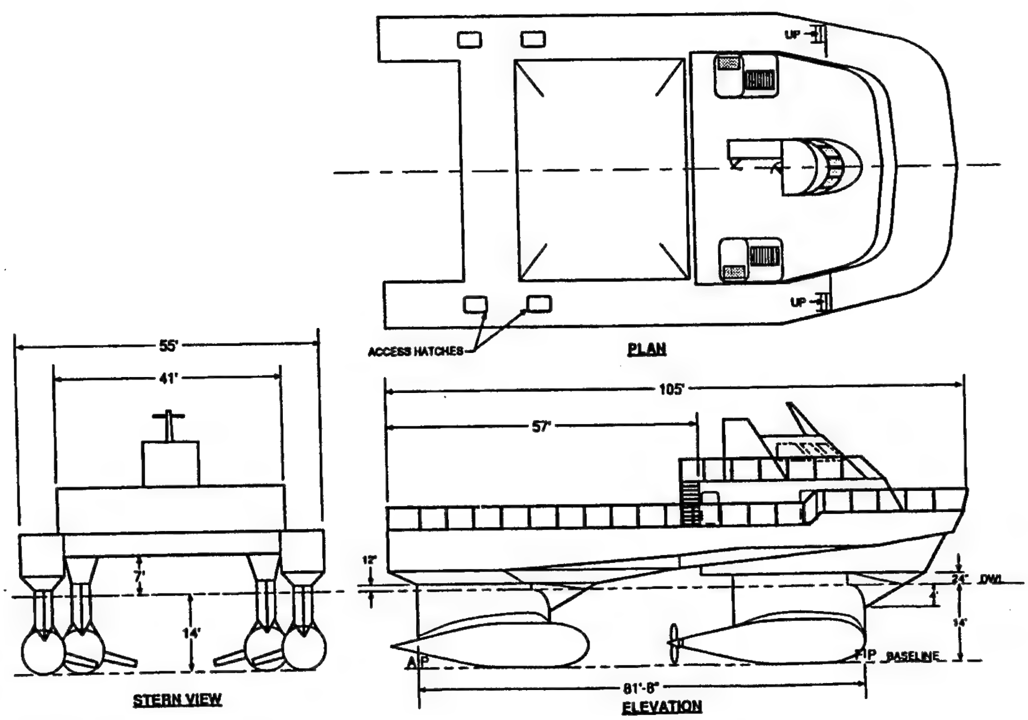

Figure 1.1. The SLICE configuration (Lockheed, 1994).

The SLICE concept was developed from the SWATH hull. A comparison of Figures 1.1 and 1.2 reveals the difference

between the two hull forms. Essentially, the SLICE design cuts the middle section out of the SWATH's struts and pods.

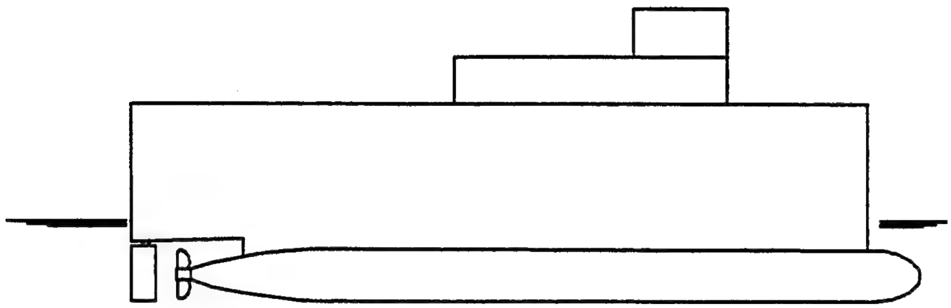

Figure 1.2. A typical SWATH vessel (Kennell, 1992).

Two accepted approaches used to extrapolate ship resistances from model data are the ITTC and Hughes methods (SNAME, 1988). These techniques break up a model resistance into subsidiary resistances and employ Reynolds and Froude scaling in different ways to predict ship resistance. Both procedures were performed on the SLICE model data.

A classical ITTC model to ship calculation was done using a single length approximation. This first guess was expected to overestimate the ship resistance since Kennell reported that the single length ITTC prediction overestimated SWATH resistances (Kennell, 1992). These results provided an upper limit by which other extrapolation techniques employed on the SLICE could be compared.

It was established that the resistance characteristics of a SWATH hull differ from those of a full displacement monohull (Kennell, 1992). The source of this difference was

the relationship between the overall length and the wetted surface area. Figure 1.3 shows equal displacement ships and Kennell documents that SWATH ships have approximately sixty percent more wetted surface area than monohulls of the same displacement (Kennell, 1992). For the same reason, one would expect the resistance characteristics of a SLICE hull to differ from those of the monohull. The single length procedure uses equivalent flat plates of the prescribed length and area for resistance predictions. A monohull may be approximated in this manner but SWATH research indicates that separate evaluation of struts and pods yields predictions which more closely match actual ship data.

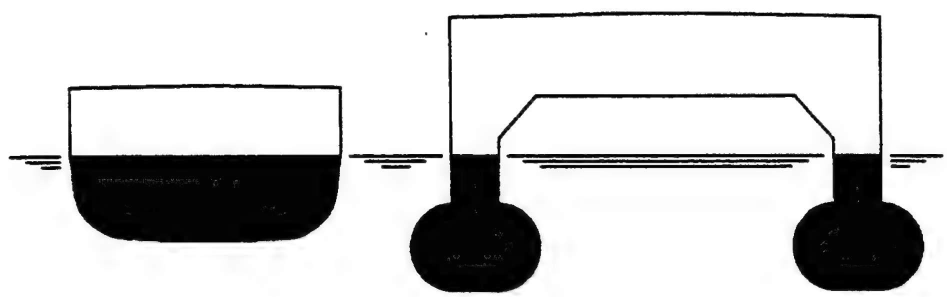

Figure 1.3. Comparison of an equal displacement monohull and SWATH (Kennell, 1992).

Using the ideas of Kennell, the SLICE wetted surface area was divided into strut and pod components (Kennell, 1992). The ITTC method was applied to extrapolate ship resistances and the Hughes method, which by definition, predicts smaller ship resistances was also applied to the sectioned hull.

Finally, a hybrid procedure analyzing the struts as wing shapes and the pods as full hull forms was developed. The hybrid examination results fell in between the ITTC and Hughes estimates.

The Lockheed Missile and Space Company, Inc. designed the SLICE and their analysis, also a variation of the Hughes method, predicted lower ship resistances than those presented here (Lockheed, 1994). Even though the drag is larger, this thesis, like Lockheed, anticipates that speeds of greater than thirty knots are achievable with the primary engine choice, depending on the overall propulsive efficiency.

II. MODELING OVERVIEW

A. FROUDE HYPOTHESIS

By Froude's hypothesis, the total resistance coefficient C_T is a function of Reynolds Number Rn and Froude Number Fn. Additionally, the total resistance coefficient may be divided into frictional and residual components. The frictional resistance coefficient C_F is a function of Reynolds Number only while the residual resistance coefficient C_R depends on both the Reynolds Number and Froude Number.

$$C_T(Rn,Fn) = C_F(Rn) + C_R(Rn,Fn) \tag{1}$$

A further subdivision of the residual resistance coefficient is possible by understanding that the wave making resistance coefficient C_{WM} is included in the residual resistance coefficient. What remains of the residual resistance coefficient is the form drag coefficient C_{FORM}. The wave making resistance coefficient is a function of the Froude Number only and the form drag coefficient is constant for geometrically similar hulls.

$$C_R(Rn,Fn) = C_{WM}(Fn) + C_{FORM} \tag{2}$$

Therefore, the total resistance coefficient is given by the following equation.

$$C_T(Rn,Fn) = C_F(Rn) + C_{WM}(Fn) + C_{FORM} \quad (3)$$

A correlation allowance C_A is added to the ship frictional and ship residual coefficients to give the ship total resistance coefficient. Figure 2.1 shows a general division of the model and ship resistance coefficients.

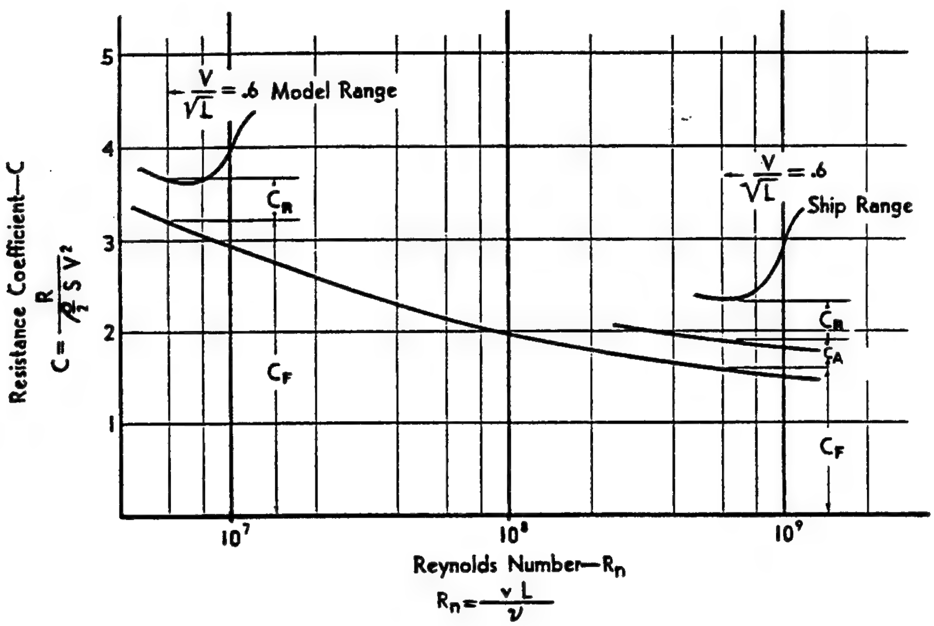

Figure 2.1. Model and ship resistance coefficients versus Reynolds Number (Gilmer and Johnson, 1982).

B. ITTC METHOD

The ITTC Method follows Froude's hypothesis for the total resistance coefficient. It proposes an equation that produces a curve on the resistance coefficient C_F versus Reynolds Number plot which represents the portion of the total coefficient due to friction as

$$C_F = \frac{0.075}{\left(\log_{10} Rn - 2\right)^2} \tag{4}$$

The ITTC method maintains the concept that the residual resistance coefficient is comprised of the wave making resistance and form drag components. The wave making resistance coefficient is dependent upon the Froude Number. For Froude scaling, the model and ship have the same Froude Numbers. Therefore, for a given Froude Number the model wave making resistance coefficient is equal to the ship wave making coefficient. Since the form drag coefficient is constant for geometrically similar vessels, the wave making and form drag coefficients can be analyzed at each Froude Number as a constant sum known as the residual resistance coefficient.

$$C_R\left(Rn, Fn\right) = C_{WM}\left(Fn\right) + C_{FORM} \tag{5}$$

In this way, an estimate of the ship total resistance coefficient may be derived from model test tank measurements. The component breakdown of the total resistance coefficient for the ITTC method is shown in Figure 2.2. In summary, the total resistance coefficient for the ITTC method is given by the following equation.

$$C_T\left(Rn, Fn\right) = C_F\left(Rn\right) + C_R\left(Rn, Fn\right) \tag{6}$$

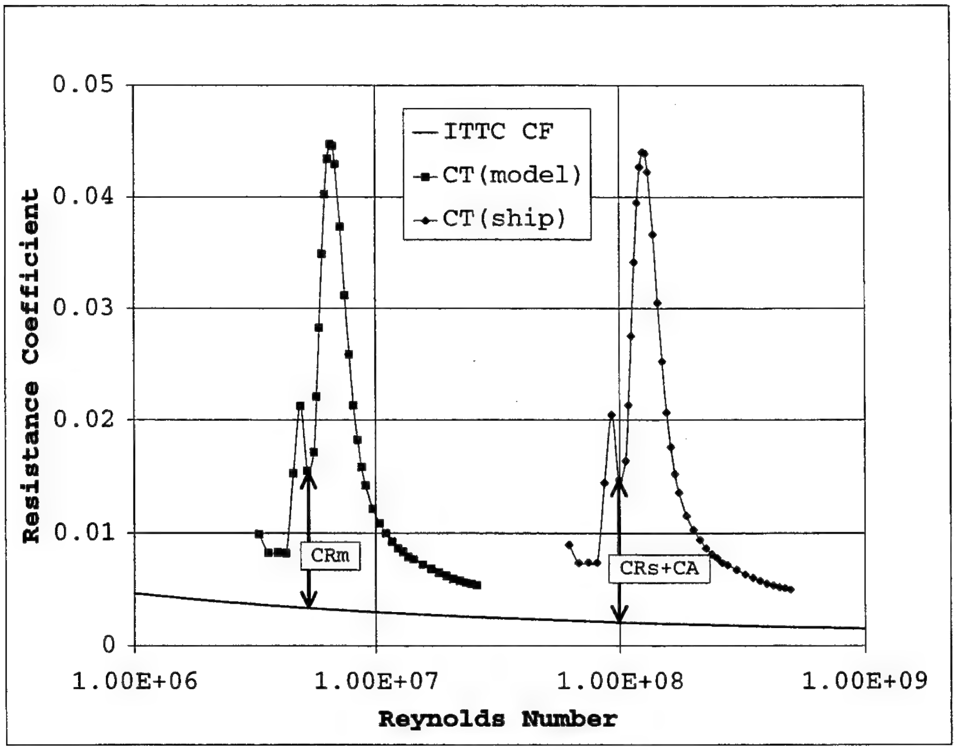

Figure 2.2. Total resistance coefficient versus Reynolds Number for an ITTC analysis.

C. HUGHES METHOD

The Hughes method suggests a variation on Froude's hypothesis and modifies the friction coefficient curve. The analysis suggests that the frictional resistance and form drag are due to viscous effects and are therefore both a function of Reynolds Number. As plotted on Figure 2.3, the Hughes curve equation for the frictional resistance coefficient C_{FO} is

$$C_{FO} = \frac{0.066}{\left(\log_{10} Rn - 2.03\right)^2} \tag{7}$$

The analysis proposes that the form drag coefficient can be related to the frictional resistance coefficient curve by some constant η.

$$C_{FORM}(Rn, Fn) = \eta\ C_{FO}(Rn) \tag{8}$$

By multiplying the frictional resistance coefficient by a form factor r, the form drag and frictional resistance components are combined into a single Reynolds dependent term. At low Froude Numbers the wave making resistance is negligible and therefore at a low speed the following holds:

$$C_T(Rn, Fn) = C_{FO}(Rn) + C_{FORM}(Rn) + \underbrace{C_{WM}(Fn)}_{0} \tag{9}$$

$$C_T(Rn, Fn) = (1+\eta) C_{FO}(Rn) \tag{10}$$

$$C_T(Rn, Fn) = r\ C_{FO}(Rn) \tag{11}$$

In this way, the form factor may be found for the hull shape. The form factor is constant for geometrically similar hulls. In general, the total resistance coefficient may be written in the form

$$C_T(Rn, Fn) = r\ C_{FO}(Rn) + C_{WM}(Fn) \tag{12}$$

The component breakdown of the total resistance coefficient is shown in Figure 2.3. The residual resistance

coefficient for the Hughes method is a function of both the Reynolds Number and the Froude Number.

$$C_R(Rn,Fn) = C_{WM}(Fn) + C_{FORM}(Rn) \qquad (13)$$

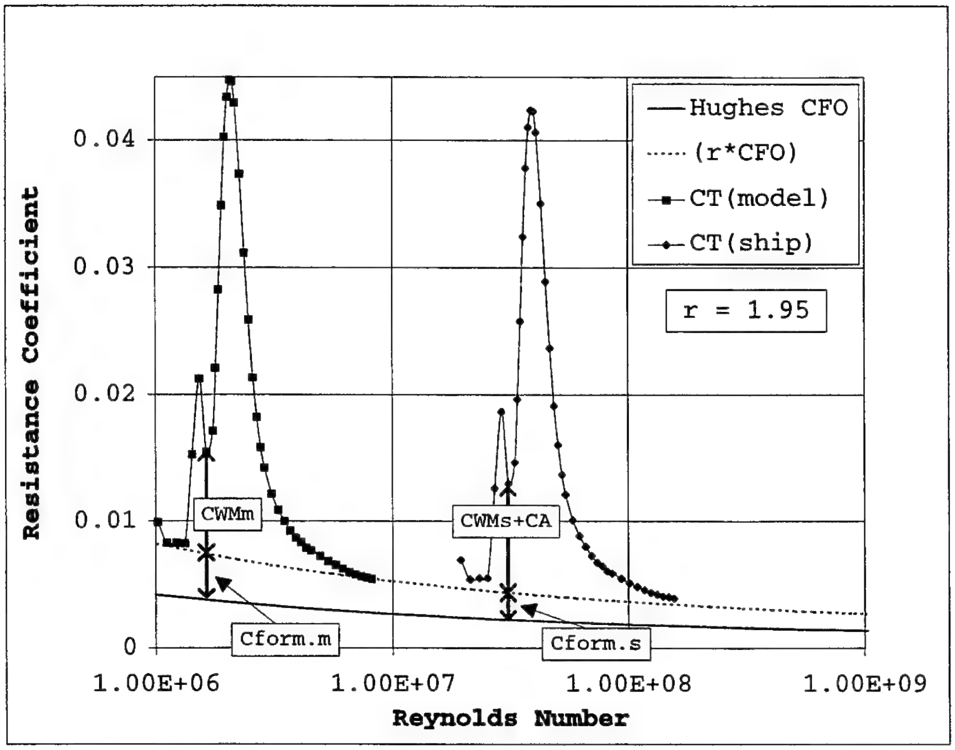

Figure 2.3. Total resistance coefficient versus Reynolds Number for the Hughes analysis.

D. MODIFIED HUGHES METHOD

A further investigation was developed in which the struts were evaluated as wing sections. By this premise, one may consider the total drag attributed to the struts as equivalent to the drag of a geometrically similar wing

shape. Using Figure 2.4, a wing drag coefficient $C_{d_{Wing}}$ was extracted.

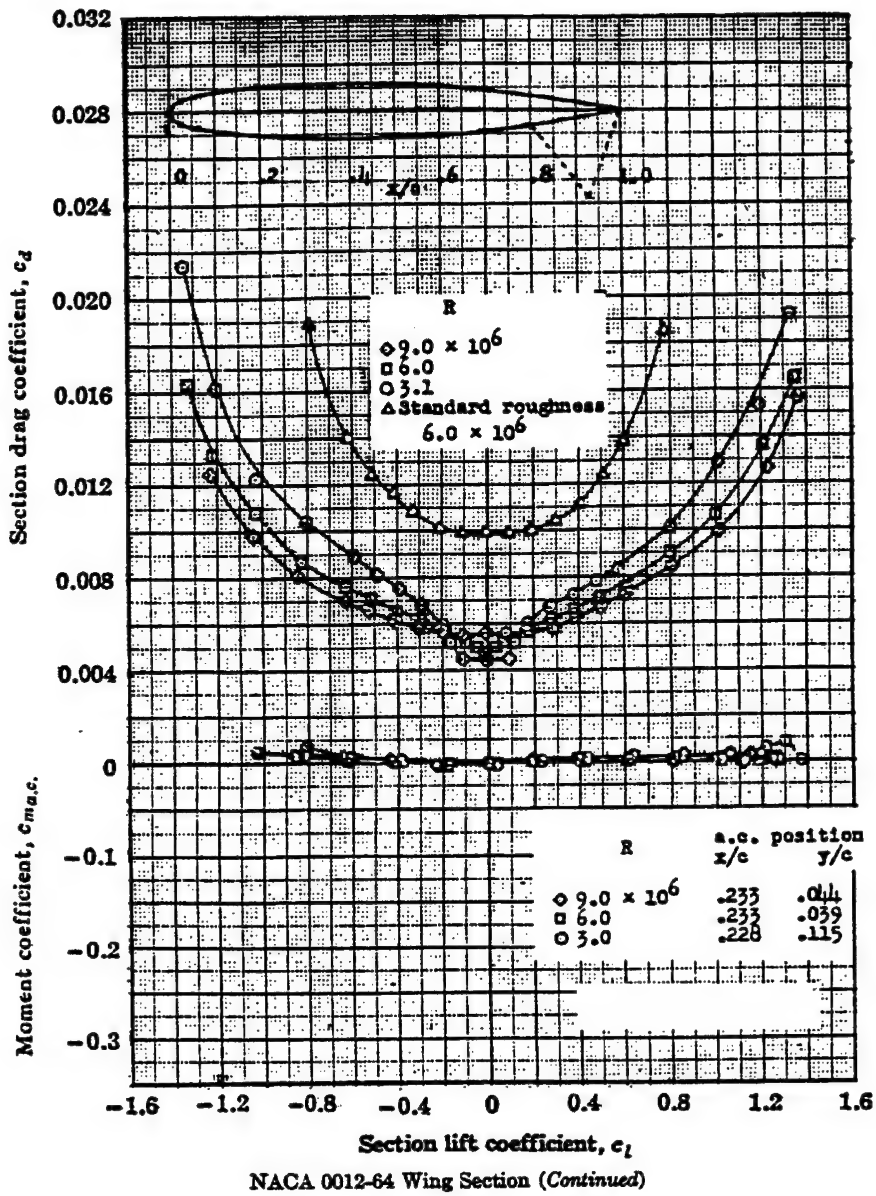

Figure 2.4. Section drag coefficient versus section lift coefficient for a NACA 0012-64 wing section (Abbott and von Doenhoff, 1959).

This wing drag coefficient however does not account for the effects of wave making resistance. Therefore, a wave making term must be added to account for its absence.

$$C_{T_{Strut}}(Rn,Fn) = C_{d_{Wing}}(Rn) + C_{WM_{Strut}}(Fn) \tag{14}$$

Applying the Froude analysis to the strut total resistance coefficient, the following may be written for the strut total drag coefficient.

$$C_{T_{Strut}}(Rn,Fn) = C_{FO_{Strut}}(Rn) + C_{WM_{Strut}}(Fn) + C_{FORM_{Strut}} \tag{15}$$

By assuming that at low Froude Numbers, in other words low speeds, the wave making resistance is negligible, the wing drag coefficient is equivalent to the strut total drag coefficient. This allows the strut form drag coefficient to be obtained by subtracting the strut frictional resistance coefficient from the strut total drag coefficient.

Because the wetted surface area was fragmented, the resistances, not the coefficients, were be used to arithmetically account for all effects. Once the portion of the form drag attributed to the struts was known, the pod form drag was calculated by subtracting the strut contribution from the overall form drag found in the Hughes analysis.

$$R_{FORM_{Pod}} = R_{FORM} - R_{FORM_{Strut}} \tag{16}$$

Due to the shape of the pods (oblong / aspect ratio) the form drag coefficient of the pods were considered functions of Reynolds Number and were therefore Reynolds scaled according to the Hughes method. The strut was approximated by a flat plat in turbulent flow with a constant form drag coefficient. Therefore, it is appropriate to separate the strut and pod form coefficients for the model to ship scaling process.

$$C_{FORM_{Pod}}(Rn,Fn) = \eta\ C_{FO_{Equiv}}(Rn) \tag{17}$$

$$C_{FORM_{Strut}} = const \tag{18}$$

The component breakdown of the total resistance coefficient is shown in Figure 2.5. Computationally, the separate resistance coefficients were found from their respective resistances in the following equation.

$$R_T(Rn,Fn) = R_{FO_{Equiv}}(Rn) + R_{FORM_{Pod}}(Rn) + R_{WM}(Fn) + R_{FORM_{Strut}} \tag{19}$$

The residual resistance coefficient for the Hughes method is a function of both the Reynolds Number and the Froude Number and was found from the summed residual resistance.

$$R_R(Rn,Fn) = R_{WM}(Fn) + R_{FORM_{Pod}}(Rn) + R_{FORM_{Strut}} \tag{20}$$

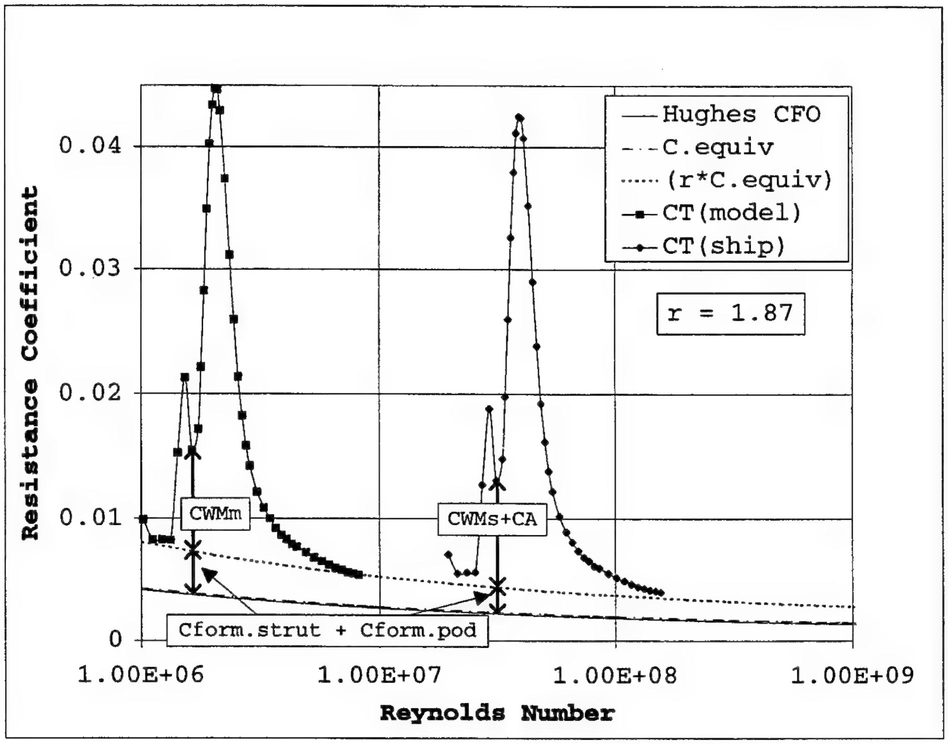

Figure 2.5. Total resistance coefficient versus Reynolds Number for the modified Hughes method.

In essence, the Hughes method has been modified such that the portion of the form drag attributed to the pods was reduced in the transfer from model to ship by Reynolds scaling while the strut portion was Froude scaled. An equivalent Hughes coefficient, found from R_{Equiv}, an equivalent resistance

$$R_{Equiv} = \left(R_{FO} + R_{FORM_{Strut}}\right) \tag{21}$$

was multiplied by the form factor r, to raise this equivalent Hughes curve to the desired value of the total

resistance coefficient specified by the Hughes Method. Alternatively, the same form factor would be found by raising the original Hughes curve to a value equal to the total resistance coefficient minus an equivalent strut form drag coefficient.

III. WETTED SURFACE AREA AND METHOD CALCULATIONS

A. DETERMINATION OF THE WETTED SURFACE AREA

The wetted surface area of the SLICE hull was calculated from the Lockheed ship drawings P1-100-01 dated 13 December 1994. The waterline used was 14 feet (Lockheed, 1994). For calculation of the wetted surface area the hull was cut into numerous sections for easier analysis. Figures 3.1 through 3.4 show how the submerged hull was subdivided. Where separate calculated surface areas overlapped, appropriate area values were subtracted form the total.

1. Wetted Surface Area One

Wetted surface area One consisted of the forward angled piece delineated in Figure 3.1 and was calculated using triangular geometry. The calculations are provided in Appendix A. The vertical depths were taken from the ship drawings (Lockheed, 1994) and the horizontal distances from the strut centerline for each station were calculated by geometry. The shortened surface chord length from stations 0 to 3, due to the intersection with the wing part of the strut, was accounted for by decreasing the horizontal distance from the centerline. The angle between centerline and surface intersection with DWL was constant at 8.1 degrees. The Simpson Rule was used to calculate the wetted surface area of one side of one piece by connecting the surface chords. Therefore, the total wetted surface area of the two forward angled pieces was four times the calculated

area of one side. To ensure accuracy, a trapezoidal rule calculation was also done.

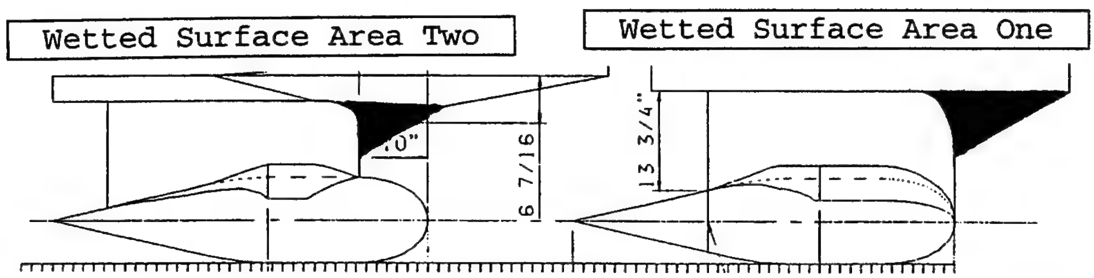

Figure 3.1. Wetted Surface Areas One and Two (Lockheed, 1994).

2. Wetted Surface Area Two

Wetted surface area Two consisted of the aft angled piece, delineated in Figure 3.1. The same procedure used to find area One was used to find area Two and the calculations are provided in Appendix A. Because the aft connections are different from the forward connections, the areas for the forward pods and the aft pods are distinct.

3. Wetted Surface Area Three

Area Three is the segment of the forward strut portion which is wing shaped as shown in Figure 3.2. It encompasses the surface from the DWL to the fillet which connects the strut to the pod. Depth measurements were taken off SHIP drawings (Lockheed, 1994) and the Simpson Rule was used to calculate surface area. To ensure accuracy, a trapezoidal rule calculation was also done. Calculations are provided in Appendix A.

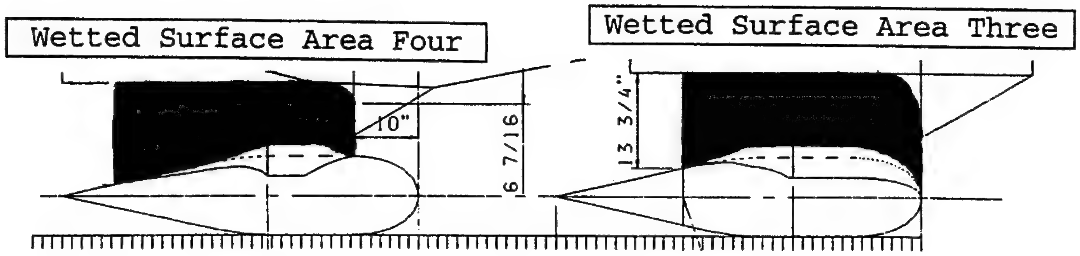

Figure 3.2. Wetted Surface Areas Three and Four (Lockheed, 1994).

4. Wetted Surface Area Four

Area Four is the segment of the aft strut portion which is wing shaped as shown in Figure 3.2. The same procedure used to find area Three was used to find area Four and the calculations are provided in Appendix A. Because the aft struts connect to the aft pods in a geometrically different way than the forward struts and pods, the fore and aft areas are different.

5. Wetted Surface Area Five

Area Five is the forward fillet, outlined in Figure 3.3 and consists of that part of the wetted surface which attaches the forward struts to the forward pods. The ship drawings (Lockheed, 1994) provided measurements to the upper and lower coordinates at ship stations. Surface chord lengths between these two points were calculated and the Simpson Rule was used to calculate the surface area. To ensure accuracy, a trapezoidal rule calculation was also done. The calculations are provided in Appendix A.

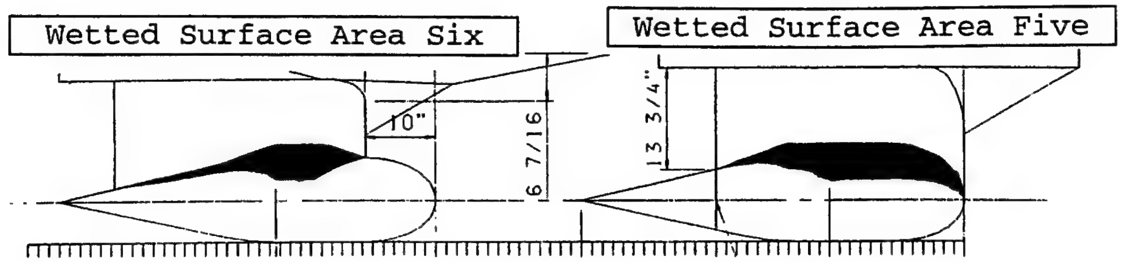

Figure 3.3. Wetted Surface Areas Five and Six (Lockheed, 1994).

6. Wetted Surface Area Six

Area Six is the aft fillet, outlined in Figure 3.3, corresponds to area Five of the forward hull. The surface was calculated the same way as the forward fillet but due to different for and aft connections, the areas for the forward segment and the aft segment are distinct. The calculations are provided in Appendix A.

7. Wetted Surface Area Seven

Wetted surface area Seven is the forward pod, outlined in Figure 3.4. Using cylindrical geometry, circumferences were calculated at each station. At stations where the pods connected to the struts and fillets, an appropriate arc lengths was subtracted from the circumference. The Simpson Rule was used to calculate surface area and a trapezoidal rule was done as a check. As expected the Trapezoidal rule supplied a smaller value since the nose section's surface is curved between stations rather than flat. The calculations are provided in Appendix A.

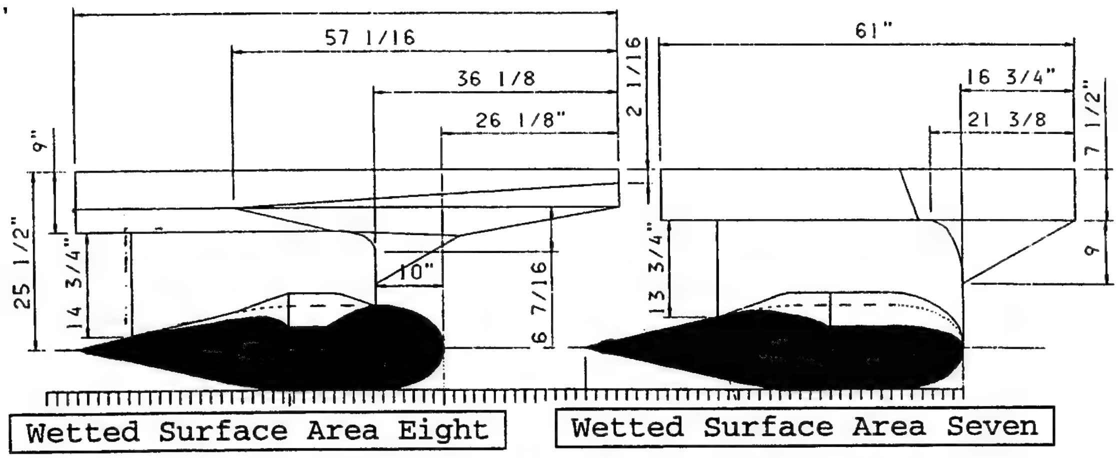

Figure 3.4. Wetted Surface Areas Seven and Eight (Lockheed, 1994).

8. Wetted Surface Area Eight

Figure 3.4 shows wetted surface area Eight which was calculated in the same manner as the forward pod. As before, the aft results differ form the forward ones because the aft connections are different from the forward connections. The calculations are provided in Appendix A.

B. ITTC PROCEDURE ON A SINGLE LENGTH

The model velocities V_M and model Froude Numbers Fn_M were taken from the Lockheed test tank data. (Lockheed, 1994) The desired range of ship velocities V_S was from 5 to 40 knots. By Froude scaling, the model Froude Number Fn_M is equal to the ship Froude Number Fn_S and with a scaling factor λ equal to 8, the model velocities were set by the following relationship.

$$V_M = \frac{V_S}{\sqrt{\lambda}} \tag{22}$$

Lockheed ship drawings were used to establish a ship wetted surface area S_S as described in the wetted surface area calculation chapter and the model wetted surface area S_M was calculated by relating the ship wetted surface area and the scale factor λ appropriately.

$$S_M = \frac{S_S}{\lambda^2} \tag{23}$$

The model total drag R_{T_M} provided by the Lockheed towing test, was the force required to move the model through the towing tank over the desired range of velocities. From the model total drag values, model total drag coefficients C_{T_M} were found. The test tank fluid density ρ_M was taken to be for fresh water at 68°F or 20°C.

$$\rho_M = \left(\frac{62.311}{32.174}\right)\frac{slugs}{ft^3} \tag{24}$$

$$C_{T_M} = \frac{R_{T_M}}{\left(\frac{1}{2}\,\rho_M S_M V_M^2\right)} \tag{25}$$

Equivalent model lengths $L_{M_{Equiv}}$ were calculated from the model Froude Numbers and model velocities where g is standard gravity. The twenty percent trim mean was taken as an average equivalent model length and used for all subsequent calculations.

$$g = 32.174 \frac{lb_m \cdot ft}{lb_f \cdot s^2} \tag{26}$$

$$L_{M_{Equiv}} = \frac{V_M^2}{gFn_M^2} \tag{27}$$

Reynolds Numbers were calculated based on the average equivalent model length and model velocities. These model Reynolds Numbers Rn_M have no true relation to the actual geometry of the model, they are only representations of flow over a flat plate of equivalent frictional length. The test tank fluid kinematic viscosity ν_M was taken to be for fresh water at 68°F or 20°C.

$$\nu_M = 1.08042 \times 10^{-5} \frac{ft^2}{s} \tag{28}$$

$$Rn_M = \frac{V_M L_{M_{Equiv}}}{\nu_M} \tag{29}$$

Using the ITTC equation, a value for the overall model frictional coefficient C_{F_M} was found and using this coefficient, a corresponding model frictional resistance R_{F_M} was calculated.

$$C_{F_M} = \frac{0.075}{\left(\log_{10} Rn_M - 2\right)^2} \tag{30}$$

$$R_{F_M} = C_{F_M}\left(\tfrac{1}{2}\rho_M S_M V_M^2\right) \tag{31}$$

The model residual resistance coefficient C_{R_M} is what remains of the model total resistance coefficient once the model frictional resistance coefficient is subtracted from it. The residual resistance is mostly due to wave making resistance and these were considered equivalent. Since the model wave making resistance coefficient is Froude scaled, it is equal to the ship wave making coefficient C_{WM_S}.

$$C_{R_M} = \left(C_{T_M} - C_{F_M}\right) = C_{WM_M} = C_{WM_S} \tag{32}$$

The model residual resistance R_{R_M} , equivalent to the model wave making resistance R_{WM_M} , was calculated from the model residual resistance coefficient.

$$R_{R_M} = C_{R_M}\left(\tfrac{1}{2}\rho_M S_M V_M^2\right) = R_{WM_M} \tag{33}$$

For the ship calculations, the ship velocities V_S and an equivalent ship length $L_{S_{Equiv}}$ were calculated using Froude scale factor relationships. Again by Froude similarity, the ship Froude Number matches the model Froude Number for corresponding speeds.

$$V_S = \sqrt{\lambda}\, V_M \tag{34}$$

$$L_{S_{Equiv}} = \lambda\, L_{M_{Equiv}} \tag{35}$$

Using the ship velocities and the equivalent ship length, equivalent ship Reynolds Numbers Rn_S were found and used to calculate ship frictional resistance coefficients C_{F_S}. A corresponding value of the ship frictional resistance R_{F_S} was found. The test tank fluid kinematic viscosity ν_M and fluid density ρ_M are for sea water at 59°F or 15°C. This is the standardized temperature for ship resistance calculations (SNAME, 1988).

$$\nu_S = 1.27908 \times 10^{-5}\,\frac{ft^2}{s} \tag{36}$$

$$\rho_S = \left(\frac{64.042}{32.174}\right)\frac{slugs}{ft^3} \tag{37}$$

$$Rn_S = \frac{V_S L_{S_{Equiv}}}{\nu_S} \tag{38}$$

$$C_{F_S} = \frac{0.075}{\left(\log_{10} Rn_S - 2\right)^2} \tag{39}$$

$$R_{F_S} = C_{F_S}\left(\tfrac{1}{2}\,\rho_S S_S V_S^2\right) \tag{40}$$

Since the SLICE hull is similar to the SWATH hull, a correlation allowance of 0.0005 was used. Based on research this value is most appropriate for SWATH vessels (Kennell, 1992). It is noted that Lockheed also used a correlation allowance of 0.0005 in their analysis (Lockheed, 1994). By Froude scaling, the ship wave making resistance

coefficient C_{WM_S} equals the model wave making resistance coefficient at corresponding velocities. Therefore, the ship total resistance coefficient C_{T_S} was found and using this coefficient, a ship total resistance R_{T_S} was resolved.

$$C_{T_S} = C_{F_S} + C_{WM_S} + C_A \tag{41}$$

$$R_{T_S} = C_{T_S}\left(\tfrac{1}{2}\rho_S S_S V_S^2\right) \tag{42}$$

The ship residual resistance coefficient was the remainder of the model total resistance coefficient once the ship frictional resistance and allowance coefficient were subtracted from it. As with the model, the residual resistance was analogous to the wave making resistance. A residual resistance was also calculated.

$$C_{R_S} = \left(C_{T_S} - C_{F_S} - C_A\right) = C_{WM_S} \tag{43}$$

$$R_{R_S} = C_{R_S}\left(\tfrac{1}{2}\rho_S S_S V_S^2\right) \tag{44}$$

C. ITTC PROCEDURE ON A SECTIONALIZED HULL

The same values for model velocities V_M, model Froude Numbers Fn_M, scaling factor λ, model wetted surface area S_M, model total drag R_{T_M}, and model total drag coefficients C_{T_M} were used. As in the previous analysis, the test tank fluid

density ρ_M and fluid kinematic viscosity ν_M were taken to be for fresh water at 68°F or 20°C.

Ship lengths L_S for each pod and strut section were taken from the ship drawings (Lockheed, 1994) and the proportional model lengths L_M were found. Then, Reynolds Numbers were calculated for each of the model sections. These model Reynolds Numbers Rn_M represent values for flow over a flat plate of equivalent frictional length.

$$Rn_M = \frac{V_M L_M}{\nu_M} \tag{45}$$

Using the ITTC equation, a value for the section's model frictional coefficient C_{F_M} was found.

$$C_{F_M} = \frac{0.075}{\left(\log_{10} Rn_M - 2\right)^2} \tag{46}$$

From the ITTC model frictional coefficients, corresponding model frictional resistances R_{F_M} were calculated for each section and then summed together to form an overall model frictional resistance.

$$R_{F_M} = C_{F_M}\left(\tfrac{1}{2}\rho_M S_M V_M^2\right) \tag{47}$$

$$R_{F_M} = \sum_{i=1}^{n} R_{F_{M_i}} \qquad n = number\ of\ sections \tag{48}$$

Once an overall frictional resistance was found, an equivalent frictional resistance coefficient $C_{F_{M_{Equiv}}}$ was found and from that an equivalent Reynolds Number $Rn_{M_{Equiv}}$ and equivalent length $L_{M_{Equiv}}$ were calculated.

$$C_{F_{M_{Equiv}}} = \frac{R_{F_M}}{\left(\frac{1}{2}\rho_M S_M V_M^2\right)} \tag{49}$$

$$Rn_{M_{Equiv}} = 10^{\left(2+\sqrt{\frac{0.075}{C_{F_{M_{Equiv}}}}}\right)} \tag{50}$$

$$L_{M_{Equiv}} = \frac{Rn_{M_{Equiv}} \nu_M}{V_M} \tag{51}$$

The model residual resistance coefficient C_{R_M} is what remains of the model total resistance coefficient once the model frictional resistance coefficient is subtracted from it. The residual resistance is mostly due to wave making resistance and these were considered equivalent. Since the model wave making resistance coefficient C_{WM_M} is Froude scaled, it is equal to the ship wave making coefficient C_{WM_S}.

$$C_{R_M} = \left(C_{T_M} - C_{F_M}\right) = C_{WM_M} = C_{WM_M} \tag{52}$$

The model residual resistance R_{R_M}, equivalent to the model wave making resistance R_{WM_M}, was calculated from the model residual resistance coefficient.

$$R_{R_M} = C_{R_M}\left(\tfrac{1}{2}\rho_M S_M V_M^2\right) = R_{WM_M} \tag{53}$$

The same ship velocities V_S, ship Froude Numbers Fn_S and ship wetted surface area S_S for the ITTC method were used in these calculations. As before, the ship fluid density ρ_S and fluid kinematic viscosity ν_S were taken to be for sea water at 59°F or 15°C.

Ship lengths L_S for each pod and strut section were taken from the ship drawings (Lockheed, 1994) and used to calculate Reynolds Numbers. These ship Reynolds Numbers Rn_S represent values for flow over a flat plate of equivalent frictional length.

$$Rn_S = \frac{V_S L_S}{\nu_S} \tag{54}$$

Using the ITTC equation, a value for the ship section's frictional coefficient C_{F_S} was found.

$$C_{F_S} = \frac{0.075}{\left(\log_{10} Rn_S - 2\right)^2} \tag{55}$$

From the ship section's ITTC frictional coefficients, corresponding ship frictional resistances R_{F_S} were calculated for each section and these were summed together to form an overall ship frictional resistance.

$$R_{F_S} = C_{F_S}\left(\tfrac{1}{2}\rho_S S_S V_S^2\right) \tag{56}$$

$$R_{F_S} = \sum_{i=1}^{n} R_{F_{S_i}} \qquad n = number\ of\ sections \tag{57}$$

Once an overall frictional resistance was found, an equivalent ship frictional resistance coefficient $C_{F_{S_{Equiv}}}$ was found and from that an equivalent ship Reynolds Number $Rn_{S_{Equiv}}$ and equivalent ship length $L_{S_{Equiv}}$ were calculated.

$$C_{F_{S_{Equiv}}} = \frac{R_{F_S}}{\left(\frac{1}{2}\rho_S S_S V_S^2\right)} \tag{58}$$

$$Rn_{S_{Equiv}} = 10^{\left(2+\sqrt{\frac{0.075}{C_{F_{S_{Equiv}}}}}\right)} \tag{59}$$

$$L_{S_{Equiv}} = \frac{Rn_{S_{Equiv}} \nu_S}{V_S} \tag{60}$$

The correlation allowance C_A was taken to be 0.0005, and the ship wave making resistance coefficient C_{WM_S} was taken to be equal to the model wave making resistance coefficient at corresponding velocities. Therefore, the ship total resistance coefficient C_{T_S} was found and using this coefficient, a ship total resistance R_{T_S} was resolved.

$$C_{T_S} = C_{F_{S_{Equiv}}} + C_{WM_S} + C_A \tag{61}$$

$$R_{T_S} = C_{T_S}\left(\frac{1}{2}\rho_S S_S V_S^2\right) \tag{62}$$

The ship residual resistance coefficient was the remainder of the model total resistance coefficient once the ship frictional resistance and allowance coefficients were subtracted from it. As with the model, the residual resistance was analogous to the wave making resistance. A residual resistance was also calculated.

$$C_{R_S} = \left(C_{T_S} - C_{F_S} - C_A\right) = C_{WM_S} \tag{63}$$

$$R_{R_S} = C_{R_S}\left(\tfrac{1}{2}\rho_S S_S V_S^2\right) \tag{64}$$

D. HUGHES PROCEDURE ON A SECTIONALIZED HULL

The values for model velocities V_M, model Froude Numbers Fn_M, scaling factor λ, model wetted surface area S_M, model total drag R_{T_M}, and model total drag coefficients C_{T_M} were the same as in previous analyses. Again, the test tank fluid density ρ_M and fluid kinematic viscosity ν_M were taken to be for fresh water at 68°F or 20°C.

Ship lengths L_S for each pod and strut section were taken from the ship drawings (Lockheed, 1994) and the proportional model lengths L_M were found. Then, Reynolds Numbers were calculated for each model section. These model Reynolds Numbers Rn_M represent values for flow over a flat plate of equivalent frictional length.

$$Rn_M = \frac{V_M L_M}{\nu_M} \tag{65}$$

Using the Hughes equation, a value for each section's model frictional coefficient C_{FO_M} was found.

$$C_{FO_M} = \frac{0.066}{\left(\log_{10} Rn_M - 2.03\right)^2} \tag{66}$$

From the Hughes model frictional coefficients, corresponding model frictional resistances R_{FO_M} were calculated for each section and then summed together to form an overall model frictional resistance.

$$R_{FO_M} = C_{FO_M}\left(\tfrac{1}{2}\rho_M S_M V_M^2\right) \tag{67}$$

$$R_{FO_M} = \sum_{i=1}^{n} R_{FO_{M_i}} \qquad n = number\ of\ sections \tag{68}$$

Once an overall frictional resistance was found, an equivalent model frictional resistance coefficient $C_{FO_{M_{Equiv}}}$ was found and from that an equivalent model Reynolds Number $Rn_{M_{Equiv}}$ and equivalent model length $L_{M_{Equiv}}$ were calculated.

$$C_{FO_{M_{Equiv}}} = \frac{R_{FO_M}}{\left(\tfrac{1}{2}\rho_M S_M V_M^2\right)} \tag{69}$$

$$Rn_{M_{Equiv}} = 10^{\left(2.03+\sqrt{\frac{0.066}{C_{FOM_{Equiv}}}}\right)} \tag{70}$$

$$L_{M_{Equiv}} = \frac{Rn_{M_{Equiv}} \nu_M}{V_M} \tag{71}$$

As explained in Chapter II, the form factor r was found by raising the Hughes curve up to the model total resistace coefficient at a low speed. Figure 2.3 shows the new curve which is the product of multiplying the form factor and the Hughes equivalent resistance coefficients The new curve is the sum of the model equivalent frictional resistance coefficient and the model form drag coefficient. From this, the model form drag coefficient C_{FORM_M} and the model form drag R_{FORM_M} were found.

$$C_{FORM_M} = C_{FO_M}(r-1) \tag{72}$$

$$R_{FORM_M} = C_{FORM_M}\left(\tfrac{1}{2}\rho_M S_M V_M^2\right) \tag{73}$$

The model wave making C_{WM_M} is what remains of the model total resistance coefficient once the model frictional resistance coefficient and model form drag coefficient are subtracted from it. Since the model wave making resistance coefficient is Froude scaled, it is equal to the ship wave making coefficient C_{WM_S}.

$$C_{WM_M} = \left(C_{T_M} - C_{FO_M} - C_{FORM_M}\right) = \left(C_{T_M} - r\,C_{FO_M}\right) = C_{WM_S} \tag{74}$$

The model residual resistance R_{R_M}, equivalent to the model wave making resistance R_{WM_M}, was calculated from the model residual resistance coefficient by the relation:

$$R_{R_M} = C_{R_M}\left(\tfrac{1}{2}\rho_M S_M V_M^2\right) = R_{WM_M} \tag{75}$$

The same ship velocities V_S, ship Froude Numbers Fn_S and ship wetted surface area S_S for the ITTC method were used in these calculations. As before, the ship fluid density ρ_S and fluid kinematic viscosity ν_S were taken to be for sea water at 59°F or 15°C.

Ship lengths L_S for each pod and strut section were taken from the ship drawings (Lockheed, 1994) and used to calculate Reynolds Numbers. These ship Reynolds Numbers Rn_S represent values for flow over a flat plate of equivalent frictional length.

$$Rn_S = \frac{V_S L_S}{\nu_S} \tag{76}$$

Using the Hughes equation, a value for the ship frictional coefficient C_{FO_S} was found for each section.

$$C_{FO_S} = \frac{0.066}{\left(\log_{10} Rn_S - 2.03\right)^2} \tag{77}$$

From the ship Hughes frictional coefficients, corresponding ship frictional resistances R_{FO_S} were

calculated for each section and then summed together to form an overall ship frictional resistance.

$$R_{FO_S} = C_{FO_S}\left(\tfrac{1}{2}\,\rho_S S_S V_S^2\right) \tag{78}$$

$$R_{FO_S} = \sum_{i=1}^{n} R_{FO_{S_i}} \qquad n = number\ of\ sections \tag{79}$$

Once an overall frictional resistance was found, an equivalent ship frictional resistance coefficient $C_{FO_{S_{Equiv}}}$ was found and from that an equivalent ship Reynolds Number $Rn_{S_{Equiv}}$ and equivalent ship length $L_{S_{Equiv}}$ were calculated.

$$C_{FO_{S_{Equiv}}} = \frac{R_{FO_S}}{\left(\tfrac{1}{2}\,\rho_S S_S V_S^2\right)} \tag{80}$$

$$Rn_{S_{Equiv}} = 10^{\left(2+\sqrt{\frac{0.075}{C_{FO_{S_{Equiv}}}}}\right)} \tag{81}$$

$$L_{S_{Equiv}} = \frac{Rn_{S_{Equiv}}\,\nu_S}{V_S} \tag{82}$$

Multiplying the ship equivalent frictional resistance coefficients by the established form factor r yields a new curve which is the sum of the ship equivalent frictional resistance coefficient and the ship form drag coefficient. Therefore the ship form drag coefficient C_{FORM_S} and the ship form drag R_{FORM_S} can be found.

$$C_{FORM_S} = C_{FO_S}(r-1) \tag{83}$$

$$R_{FORM_S} = C_{FORM_S}\left(\tfrac{1}{2}\rho_S S_S V_S^2\right) \tag{84}$$

The correlation allowance C_A was taken to be 0.0005, and the ship wave making resistance coefficient C_{WM_S} was taken to be equal to the model wave making resistance coefficient at corresponding velocities. Therefore, the ship total resistance coefficient C_{T_S} was found and using this coefficient, a ship total resistance R_{T_S} was resolved.

$$C_{T_S} = \left(C_{FO_{S_{Equiv}}} + C_{FORM_S} + C_{WM_S} + C_A\right) \tag{85}$$

$$R_{T_S} = C_{T_S}\left(\tfrac{1}{2}\rho_S S_S V_S^2\right) \tag{86}$$

The ship residual resistance coefficient C_{R_S} was the remainder of the model total resistance coefficient once the ship frictional resistance and allowance coefficients were subtracted from it. The residual resistance R_{R_S} includes the wave making effects and the form drag.

$$C_{R_S} = \left(C_{T_S} - C_{FO_S} - C_A\right) = \left(C_{WM_S} + C_{FORM_S}\right) \tag{87}$$

$$R_{R_S} = C_{R_S}\left(\tfrac{1}{2}\rho_S S_S V_S^2\right) \tag{88}$$

E. MODIFIED HUGHES PROCEDURE ON A SECTIONALIZED HULL

For this analysis, the values for model velocities V_M, model Froude Numbers Fn_M, scaling factor λ, model wetted surface area S_M, model total drag R_{T_M}, and model total drag coefficients C_{T_M} were the same as used in the previous analyses. Again, the test tank fluid density ρ_M and fluid kinematic viscosity ν_M were taken to be for fresh water at 68°F or 20°C.

Ship lengths L_S for each pod and strut section were taken from the ship drawings (Lockheed, 1994) and the proportional model lengths L_M were found. Then, Reynolds Numbers were calculated for each model section. These model Reynolds Numbers Rn_M represent values for flow over a flat plate of equivalent frictional length.

$$Rn_M = \frac{V_M L_M}{\nu_M} \tag{89}$$

Using the Hughes equation, a value for each section's model frictional coefficient C_{FO_M} was found.

$$C_{FO_M} = \frac{0.066}{\left(\log_{10} Rn_M - 2.03\right)^2} \tag{90}$$

From the Hughes model frictional coefficients, corresponding model frictional resistances R_{FO_M} were calculated for each section and then summed together to form an overall model frictional resistance.

$$R_{FO_M} = C_{FO_M}\left(\tfrac{1}{2}\rho_M S_M V_M^2\right) \tag{91}$$

$$R_{FO_M} = \sum_{i=1}^{n} R_{FO_{M_i}} \qquad n = number\ of\ sections \tag{92}$$

Once an overall frictional resistance was found, an equivalent model frictional resistance coefficient $C_{FO_{M_{Equiv}}}$ was found and from that an equivalent model Reynolds Number $Rn_{M_{Equiv}}$ and equivalent model length $L_{M_{Equiv}}$ were calculated.

$$C_{FO_{M_{Equiv}}} = \frac{R_{FO_M}}{\left(\tfrac{1}{2}\rho_M S_M V_M^2\right)} \tag{93}$$

$$Rn_{M_{Equiv}} = 10^{\left(2.03+\sqrt{\frac{0.066}{C_{FO_{M_{Equiv}}}}}\right)} \tag{94}$$

$$L_{M_{Equiv}} = \frac{Rn_{M_{Equiv}} \nu_M}{V_M} \tag{95}$$

Here is the modification to the Hughes Method. Rather than consider it as a single term, the form drag was further subdivided into strut and pod components. By doing this, results from a separate analysis of the strut were incorporated into the model research. In particular, the struts were investigated as wing shapes whose form drag coefficient was a constant.

The wing chosen which most closely resembled the struts was NACA 0012-64. Using Figure 3.3, a wing drag coefficient $C_{d_{Wing}} = 0.0044$ was extracted. The wave making resistance of the strut was taken to be negligible at a low Froude Number. The Froude Number chosen was where the model total resistance coefficient was minimum at low speeds. For a Froude Number of $Fn = 0.2$, the model strut frictional resistance coefficient was $C_{FO_{Strut_M}} = 0.004120136$ and this was subtracted from the wing drag coefficient to determine the strut form drag coefficient $C_{FORM_{Strut}}$.

$$C_{Form_{Strut}} = C_{d_{Wing}} - C_{FO_{Strut_M}} = 0.000279864 \tag{96}$$

The model strut form drag $R_{FORM_{Strut_M}}$ was found using the model strut wetted surface area S_{Strut_M}. The strut surface area was taken as the sum of wetted surface areas One, Two, Three, Four, Five, and Six.

$$R_{FORM_{Strut_M}} = C_{FORM_{Strut}} \left(\tfrac{1}{2} \rho_M S_{Strut_M} V_M^2 \right) \tag{97}$$

Then the model frictional resistance and the model strut form drag were added together to find a single equivalent coefficient C_{Equiv_M} which could then be multiplied by the form factor r to raise the Hughes curve to the model total at low Froude Numbers.

$$C_{Equiv_M} = \frac{\left(R_{FO_M} + R_{FORM_{Strut_M}} \right)}{\left(\tfrac{1}{2} \rho_M S_M V_M^2 \right)} \tag{98}$$

$$R_{Equiv_M} = C_{Equiv_M}\left(\tfrac{1}{2}\rho_M S_M V_M^2\right) \tag{99}$$

The difference between the value multiplied by the form factor and the premultiplied value was set equal to the model pod form drag $R_{Form_{Pod_M}}$. The corresponding model pod from drag coefficient $C_{FORM_{Pod_M}}$ was calculated using the model pod wetted surface area S_{Pod_M}. The pod wetted surface area was taken as the sum of wetted surface areas Seven and Eight.

$$R_{Form_{Pod_M}} = (r-1)\, R_{Equiv_M} \tag{100}$$

$$C_{FORM_{Pod_M}} = \frac{R_{FORM_{Pod_M}}}{\left(\tfrac{1}{2}\rho_M S_{Pod_M} V_M^2\right)} \tag{101}$$

The total model form drag was the strut form drag plus the pod form drag and using the entire model wetted surface area a model form drag coefficient was calculated.

$$R_{FORM_M} = R_{FORM_{Strut_M}} + R_{FORM_{Pod_M}} \tag{102}$$

$$C_{FORM_M} = \frac{R_{FORM_M}}{\left(\tfrac{1}{2}\rho_M S_M V_M^2\right)} \tag{103}$$

The model wave making C_{WM_M} was found by subtracting the model frictional resistance coefficient and model form drag coefficient from the model total resistance coefficient. Since the model wave making resistance coefficient is Froude

scaled, it is equal to the ship wave making coefficient C_{WM_S} at comparable speeds. Additionally, the model wave making resistance R_{WM_M}, was calculated.

$$C_{WM_M} = \left(C_{T_M} - C_{FO_{M_{Equiv}}} - C_{FORM_M} \right) = C_{WM_S} \tag{104}$$

$$R_{WM_M} = C_{WM_M} \left(\tfrac{1}{2} \rho_M S_M V_M^2 \right) \tag{105}$$

The model residual resistance coefficient C_{R_M} is what remains of the model total resistance coefficient once the equivalent model frictional resistance coefficient is subtracted from it. The model residual resistance R_{R_M} includes the wave making resistance and the form drag.

$$C_{R_M} = \left(C_{T_M} - C_{FO_{M_{Equiv}}} \right) = \left(C_{WM_M} + C_{FORM_M} \right) \tag{106}$$

$$R_{R_M} = C_{R_M} \left(\tfrac{1}{2} \rho_M S_M V_M^2 \right) \tag{107}$$

The same ship velocities V_S, ship Froude Numbers Fn_S and ship wetted surface area S_S for the ITTC method were used in these calculations. As before, the ship fluid density ρ_S and fluid kinematic viscosity ν_S were taken to be for sea water at 59°F or 15°C.

Ship lengths L_S for each pod and strut section were taken from the ship drawings (Lockheed, 1994) and used to calculate Reynolds Numbers. These ship Reynolds Numbers Rn_S

represent values for flow over a flat plate of equivalent frictional length.

$$Rn_S = \frac{V_S L_S}{\nu_S} \tag{108}$$

Using the Hughes equation, a value for the ship frictional coefficient C_{FO_S} was found for each section.

$$C_{FO_S} = \frac{0.066}{\left(\log_{10} Rn_S - 2.03\right)^2} \tag{109}$$

From the ship Hughes frictional coefficients, corresponding ship frictional resistances R_{FO_S} were calculated for each section and then summed together to form an overall ship frictional resistance.

$$R_{FO_S} = C_{FO_S}\left(\tfrac{1}{2}\,\rho_S S_S V_S^2\right) \tag{110}$$

$$R_{FO_S} = \sum_{i=1}^{n} R_{FO_{S_i}} \qquad n = number\ of\ sections \tag{111}$$

Once an overall frictional resistance was found, an equivalent ship frictional resistance coefficient $C_{FO_{S_{Equiv}}}$ was found and from that an equivalent ship Reynolds Number $Rn_{S_{Equiv}}$ and equivalent ship length $L_{S_{Equiv}}$ were calculated.

$$C_{FO_{S_{Equiv}}} = \frac{R_{FO_S}}{\left(\tfrac{1}{2}\,\rho_S S_S V_S^2\right)} \tag{112}$$

$$Rn_{S_{Equiv}} = 10^{\left(2+\sqrt{\frac{0.075}{C_{FOS_{Equiv}}}}\right)} \tag{113}$$

$$L_{S_{Equiv}} = \frac{Rn_{S_{Equiv}} \nu_S}{V_S} \tag{114}$$

Since the strut form drag coefficient $C_{FORM_{Strut}}$ was taken as constant, the ship strut form drag $R_{FORM_{Strut_S}}$ was found using the ship strut wetted surface area S_{Strut_S}.

$$R_{FORM_{Strut_S}} = C_{FORM_{Strut}}\left(\tfrac{1}{2}\rho_S S_{Strut_S} V_S^2\right) \tag{115}$$

Then the ship frictional resistance and the ship strut form drag were added together to find a single equivalent coefficient C_{Equiv_S} which was multiplied by the form factor r to raise the Hughes curve.

$$C_{Equiv_S} = \frac{\left(R_{FO_S} + R_{FORM_{Strut_S}}\right)}{\left(\tfrac{1}{2}\rho_S S_S V_S^2\right)} \tag{116}$$

$$R_{Equiv_S} = C_{Equiv_S}\left(\tfrac{1}{2}\rho_S S_S V_S^2\right) \tag{117}$$

The difference between the value multiplied by the form factor and the premultiplied value was set equal to the ship pod form drag $R_{Form_{Pod_S}}$. The corresponding ship pod from drag

coefficient $C_{FORM_{Pod_S}}$ was calculated using the ship pod wetted surface area S_{Pod_S}.

$$R_{Form_{Pod_S}} = (r-1)\, R_{Equiv_S} \tag{118}$$

$$C_{FORM_{Pod_S}} = \frac{R_{FORM_{Pod_S}}}{\left(\frac{1}{2}\, \rho_S S_{Pod_S} V_S^2\right)} \tag{119}$$

The total ship form drag R_{FORM_S} was the strut form drag plus the pod form drag and using the entire ship wetted surface area, a ship form drag coefficient C_{FORM_S} was found.

$$R_{FORM_S} = R_{FORM_{Strut_S}} + R_{FORM_{Pod_S}} \tag{120}$$

$$C_{FORM_S} = \frac{R_{FORM_S}}{\left(\frac{1}{2}\, \rho_S S_S V_S^2\right)} \tag{121}$$

Since the wave making resistance coefficient is Froude scaled, the ship wave making resistance coefficient C_{WM_S} is equal to the model wave making coefficient C_{WM_M}. The corresponding ship wave making resistance R_{WM_S}, was then quantified.

$$C_{WM_S} = C_{WM_M} \tag{122}$$

$$R_{WM_S} = C_{WM_S}\left(\frac{1}{2}\, \rho_S S_S V_S^2\right) \tag{123}$$

With a correlation allowance C_A of 0.0005, the ship total resistance coefficient C_{T_S} was found and using this coefficient, the ship total resistance R_{T_S} was resolved.

$$C_{T_S} = \left(C_{FO_{S_{Equiv}}} + C_{FORM_S} + C_{WM_S} + C_A \right) \tag{124}$$

$$R_{T_S} = C_{T_S} \left(\tfrac{1}{2} \rho_S S_S V_S^2 \right) \tag{125}$$

The ship residual resistance coefficient C_{R_S} was the remainder of the model total resistance coefficient once the ship frictional resistance and allowance coefficients were subtracted from it. The residual resistance R_{R_S} includes the wave making effects and the form drag.

$$C_{R_S} = \left(C_{T_S} - C_{FO_{S_{Equiv}}} - C_A \right) = \left(C_{WM_S} + C_{FORM_S} \right) \tag{126}$$

$$R_{R_S} = C_{R_S} \left(\tfrac{1}{2} \rho_S S_S V_S^2 \right) \tag{127}$$

IV. DISCUSSION OF RESULTS

A. METHOD RESULTS

1. ITTC Single Length Analysis

As previously explained, the ITTC single length analysis, provided in Appendix B, used the Lockheed Froude Numbers to set the model length. Figure 4.1 shows the test tank model drag divided into frictional and residual components. The frictional portion, steadily increases with velocity and the residual resistance is just the difference between the total and frictional resistances. The frictional resistance was Reynolds scaled to predict the ship quantity. Since the ITTC method follows the classical Froude resistance procedure, the residual resistance was not divided into form and wave making components. The entire residual element was Froude scaled to estimate the ship residual component. Figure 4.2 shows the result of combining the ship frictional and ship residual resistances.

For both the model and ship calculations the major component of the total was the residual resistance. This suggested a need to more closely examine the Froude scaled resistances of the SLICE.

The most noticeable characteristic of Figures 4.1 and 4.2 are the two humps. These humps can be related to similar findings with SWATH hulls. Plots of residual resistance coefficients versus Froude Number of SWATH vessels exhibit prismatic humps followed by primary humps (Kennell, 1992). Figure 4.3 shows such a plot for a SWATH

vessel and Figures 4.4 and 4.5 show similar plots for the SLICE model and ship. Whereas the prismatic hump for a SWATH vessel is generally found near a Froude Number of 0.3, the prismatic hump for the SLICE is shifted left to a Froude Number of 0.23. Similarly, the primary hump of a SWATH is found near a Froude Number of 0.5 while the hump appears at 0.31 for the SLICE. These figures show that the residual resistance is the major component of the total in mid-range speeds.

2. ITTC Sectionalized Hull Analysis

The ITTC sectionalized hull analysis is provided in Appendix B. By sectioning the hull, the portion of the test tank model drag associated with friction was increased. Thus, a larger part of the total resistance was dependent on the Reynolds Number and a smaller part was dependent on the Froude Number. Although an equivalent Froude Number based on the equivalent length could be found, the Froude Number used was the same as in the single length calculations. As Figure 4.6 shows, at high speeds the model's frictional percentage was greater than the residual percentage. In the previous analysis, the residual resistance percentage was always greater than the frictional quantity. The result of altering the relative Reynolds and Froude Number dependence in this way was a decrease in predicted ship total resistance, most noticeably at higher speeds.

Although the model's frictional resistance was greater than the residual portion at high speeds, Figure 4.7 shows the same was not true for the ship. This occurs because

when predicting ship quantities, the Froude scaled resistances increase more than the Reynolds scaled ones.

Figures 4.8 and 4.9 show that the prismatic and primary humps are located at the same Froude Numbers as in the previous analysis and there is no sign of an additional hump at higher Froude Numbers. The model friction-residual switch which was shown in Figure 4.6 appears in Figure 4.8 at the corresponding Froude Number. As in Figure 4.7, Figure 4.9 shows that there is not a switch once the quantities have been expanded to the ship. As before, the residual resistance coefficient continues to taper off after the primary hump. And, as in the first case, the residual was the primary source of resistance throughout the speed range of the ship.

3. Hughes Sectionalized Hull Analysis

It was decided to more closely examine the Froude scaled resistances of the SLICE hull. Trying a different approach, the Hughes method was chosen because it further breaks down the residual resistance into form and wave making components. From previous discussion, it was shown that the form drag could be Reynolds scaled and the wave making Froude scaled. The Hughes sectionalizeded hull analysis is provided in Appendix B.

Integral to the Hughes method is the idea that at low Froude Numbers, the wave making resistance is negligible. In fact, this idea was used to find the form factor. Figures 4.10 and 4.11 show the frictional and residual breakdown for this approach. In order to compare this analysis with the ITTC methods, it was necessary to show the

resistance division as a function of the Reynolds and Froude Numbers. Figures 4.12 and 4.13 show the dramatic shift in relative Froude and Reynolds Number dependencies of the Hughes approach. Very apparent is that at high speeds the total drag is almost entirely due to Reynolds dependent resistances whereas for the ITTC cases, the Froude scaled component was dominant.

Figures 4.14 through 4.17 show the plots of resistance coefficients vs. Froude Number for this method. As in the ITTC analyses, once the Froude Number is greater than 0.3, the residual and total coefficients taper off and there is no sign of another hump or increase.

Figures 4.18 and 4.19 show the model division and ship predicted composition of the residual resistance. From the above investigation, an important concept of the procedure was revealed. This method predicts very little wave making resistance at high speeds for the SLICE hull. Note that the Froude scaled resistance equals the wave making resistance. The residual resistance of the sectionalized Hughes analysis is almost entirely from the form drag. A video of the model in the test tank supports the concept of small wave generation at high speeds.

4. Modified Hughes Sectionalized Hull Analysis

Recall that for Froude's hypothesis and the ITTC scaling procedure, the form drag component was Froude scaled, i.e., constant for each Froude Number. But, in the Hughes analysis, all of the form drag was Reynolds scaled. Since it played such an important role in the Hughes method, a further subdivision of the form drag was undertaken such

that the pod portion was Reynolds scaled and the strut portion was Froude scaled. The modified Hughes sectionalized hull analysis is provided in Appendix B.

Figures 4.20 through 4.23 show the frictional and residual breakdown for the hybrid procedure. In order to compare this analysis with the ITTC methods, the resistance was divided into parts which were functions of the Reynolds and Froude Numbers. Figures 4.24 through 4.27 show that this alteration only slightly shifts the relative Reynolds and Froude Number dependencies back toward the ITTC ratios. Figures 4.28 and 4.29 can be compared to Figures 4.18 and 4.19 of the Hughes method for the purpose of showing the results of varying the residual resistance dependency.

Because of the shift toward Froude scaling, the predicted ship total resistance for this method was slightly higher than the sectionalized Hughes method. It was still considerably lower than both the ITTC analyses.

B. COMPARISON OF METHOD RESULTS

1. Frictional Resistance Comparison

Figure 4.30 compares the model frictional resistance components of the various methods. The single length method's percentage of the model total resistance was less than the sectioned hull methods. The Hughes and modified Hughes methods used the same frictional resistance values. Figure 4.30 also includes the Lockheed skin friction which was greater than classical ITTC and Hughes assessments. By definition, the Hughes equation yields lower frictional resistance coefficients than the ITTC equation and the two

sectioned hull resistance curves of Figure 4.30 show that. Figure 4.31 shows the ship frictional resistances and the Lockheed ship skin friction. Because they were all Reynolds scaled, the ship frictional resistance curves follow the same trend as the model curves.

2. Residual Resistance Comparison

Figure 4.32 compares the model residual resistances for the various procedures. Also plotted was the Lockheed residual which taken as equal to the Lockheed sum minus the Lockheed skin friction. The single length method gave a larger percentage of the total to the residual resistance compared to the sectioned hull approaches. Note that the Hughes and modified Hughes methods have the same model residual resistances.

Figure 4.33 shows the predicted ship residual resistances for the procedures. The residual resistance was Froude scaled in the ITTC methods but was Reynolds scaled in the Hughes method. The modified Hughes method combined both Reynolds and Froude scaling to predict the ship residual resistance. The figure shows that Froude scaling resulted in higher predicted ship quantities when compared to equivalent Reynolds scaling. Since the modified Hughes method was a combination of the two scaling procedures, the predicted values fell in between the ITTC and Hughes estimates.

Figure 4.34 compares the division of the model residual resistance for the Hughes and modified Hughes methods. Both methods started with the same model total residual resistance and had the essentially the same wave making and

form drag components. Because the form factors were only taken to two decimal points, slight differences on the order of less than a pound do exist between the two method's component values. Since the model figure is only a synopsis of the data, Figure 4.34 only shows one curve for each of these resistance constituents. The modified Hughes method division of strut and pod form drags were also plotted.

Figure 4.35 shows the division of the predicted ship residual resistances for the Hughes and modified Hughes methods. The figure shows that the modified Hughes method predicted higher overall ship residual resistances. The ship wave making resistances for both methods was the same since it was Froude scaled in both instances. Although not explicitly calculated, the predicted ship pod drag of the Hughes method matched the modified Hughes value since it was Reynolds scaled in both methods. Therefore, the source of the increased predicted ship residual resistance was the strut form drag. It was identified that Froude scaling resulted in higher predicted ship values when compared to Reynolds scaling. Since the strut form drag was Froude scaled in the modified Hughes Method, its value was greater than the Hughes method Reynolds scaled counterpart.

From this investigation, one can see that for the modified Hughes method, any variation of the wetted surface area division would result in a ship residual resistance somewhere between the higher ITTC sectioned hull estimate and the lower Hughes sectioned hull estimate. In other words, if the residual resistance has any combination of Reynolds and Froude scaling, the resulting quantity will lie in between the Froude scaled ITTC method and the Reynolds scaled Hughes method.

3. Reynolds Scaled Resistances

Figure 4.36 compares the Reynolds scaled portion of the model resistance for each method and also includes the Lockheed skin friction for the model. The Reynolds resistance equaled the frictional resistance for both the ITTC methods. The Reynolds resistance of the Hughes method included both the frictional and form drag components. The Reynolds scaled resistance of the modified Hughes method was comprised of the frictional resistance and the pod portion of the form drag since the strut drag was Froude scaled.

Figure 4.37 shows the result of Reynolds scaling the model resistances of Figure 4.36. The relative order of the ship curves remained the same. In the residual resistance discussion it was shown that Reynolds scaling predicts lower ship quantities when compared to Froude scaling. It will be shown that the methods which Reynolds scaled larger percentages of the model's total resistance predicted lower ship total resistances.

4. Froude Scaled Resistances

Figure 4.38 compares the Froude scaled portion of the model resistance for each method. The figure also includes the Lockheed residual which was taken as the Lockheed sum minus the Lockheed skin friction. The Froude resistance equaled the residual resistance for both the ITTC methods. The Froude resistance of the Hughes method was the wave making component only and the Froude scaled resistance of

the modified Hughes method included both the wave making and strut portion of the form drag.

Figure 4.39 shows the result of Froude scaling the model resistances of Figure 4.38. The relative order remained the same. It will be shown that assigning larger percentages of the model's total resistance to Froude scaling results in higher ship total resistances since Froude scaling predicts higher ship quantities compared to Reynolds scaling.

The Lockheed residuals were provided in Figures 4.38 and 4.39 for comparative purposes only. It was not within the scope of this thesis to evaluate Lockheed's analysis. It is sufficient to note that the Lockheed evaluation of residual resistance varied from this thesis procedure as evidenced by the difference in model and ship curve shapes for the Lockheed residual resistance.

5. Total Resistance Comparison

All methods started with the same model total resistance. Figure 4.40 compares the predicted ship resistances from each method and Table 1 ranks the ship totals, the frictional and residual divisions of the model and ship. The Lockheed sum, also plotted in Figure 4.40, was less than all analyses covered in the thesis.

The Reynolds and Froude scaled resistance comparison provided the best insight into the analyses of the thesis. Previously, it was stated that Froude scaling a resistance resulted in higher ship values compared to Reynolds scaling. Since the ITTC methods Froude scaled all residual resistances, the ITTC methods predicted the highest ship

total resistances. The Hughes method Reynolds scaled all its residual resistance and therefore predicted the lowest total resistance. The modified Hughes method fell between the ITTC and Hughes method because it applied both Reynolds and Froude scaling to portions of its residual resistance. The sectioned hull procedure provided lower ship total resistances compared to the single length procedure. Table 2 summarizes the Reynolds and Froude Number scaling results.

Rank of Quantities (highest=1, lowest=5)	Model R_F	Model R_R	Ship R_F	Ship R_R	Ship R_T
ITTC Single Length	5	1	5	1	1
ITTC Sectioned Hull	2	4	2	2	2
Hughes Sectioned Hull	3	2	3	4	4
Modified Hughes	3	2	3	3	3
Lockheed	1	5	1	5	5

Table 1. Comparison of method derived frictional, residual and total resistances.

Rank of Quantities (highest=1, lowest=4)	Model R_{Rn}	Model R_{Fn}	Ship R_{Rn}	Ship R_{Fn}	Ship R_T
ITTC Single Length	4	1	4	1	1
ITTC Sectioned Hull	3	2	3	2	2
Hughes Sectioned Hull	1	4	1	4	4
Modified Hughes	2	3	2	3	3

Table 2. Comparison of Reynolds and Froude scaled resistance components.

C. PROPULSION

The ship horsepower or SHP defines whether the ship will meet the desired speed of thirty knots. There are three engines under consideration for the SLICE. The Lycoming TF 40 is the highest rated at 3994 horsepower for continuous operation. With two engines installed and accounting for losses, the delivery of 6850 total installed horsepower is estimated for sustained operation (Lockheed, 1994).

Figure 4.41 shows the predicted SHP versus ship speed and Figure 4.42 shows a close-up of thirty knots. The following observations can be made concerning the desire to cruise at thirty knots. At thirty knots, only the ITTC single length approach estimates a larger horsepower requirement than what the proposed engines can deliver. All other methods suggest that the planned engineering configuration will propel the ship at speeds of greater than thirty knots for sustained operations.

The effective horsepower, EHP, is a means by which a propulsion plant's efficiency can be labeled. It is found by relating the ship total resistance R_{T_S}, in pounds force, and the ship velocity V_S, in feet per second. The 550 in the denominator converts the value to horsepower.

$$EHP = \frac{R_{T_S} V_S}{550} \tag{128}$$

The SHP is found by dividing the effective horsepower EHP by some propulsive coefficient, PC, here equal to 0.73 (Lockheed, 1994).

$$SHP = \frac{EHP}{PC} \tag{129}$$

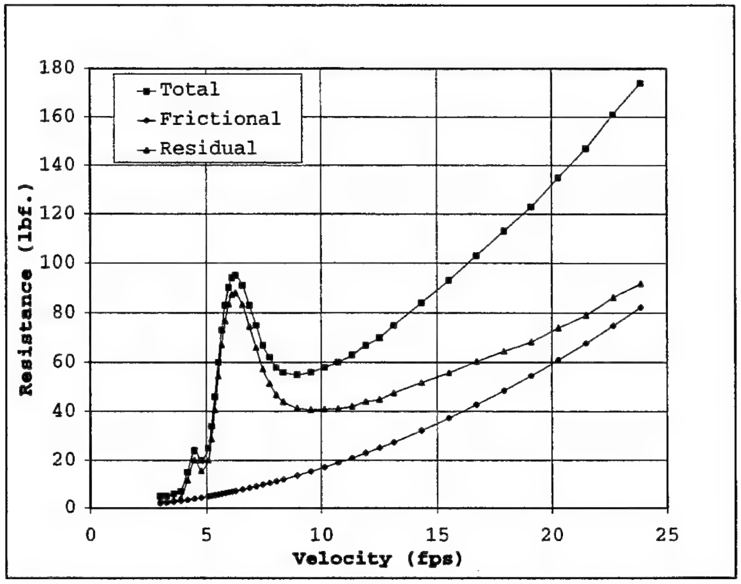

Figure 4.1. ITTC model resistances versus model velocity for a single length analysis of the SLICE hull.

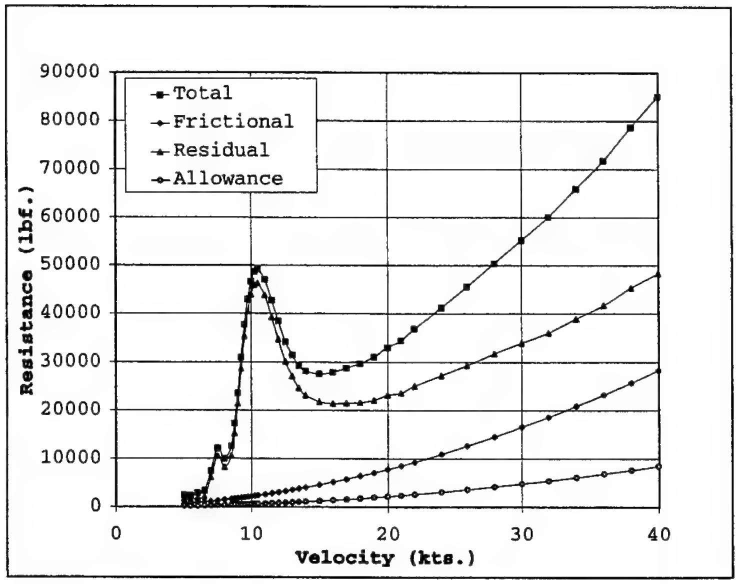

Figure 4.2. ITTC ship resistances versus ship velocity for a single length analysis of the SLICE hull.

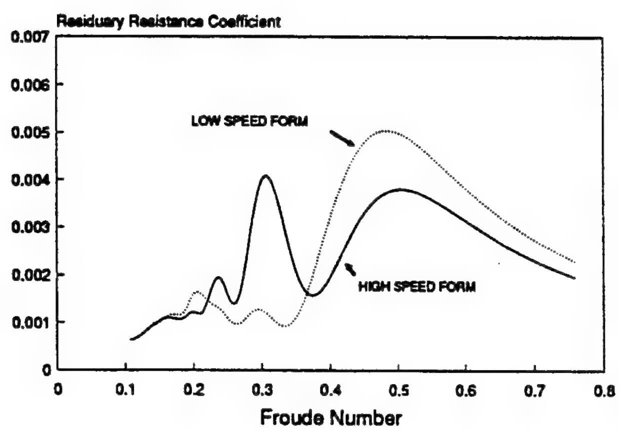

Figure 4.3. Residuary resistance coefficients versus Froude Number (Kennell, 1992).

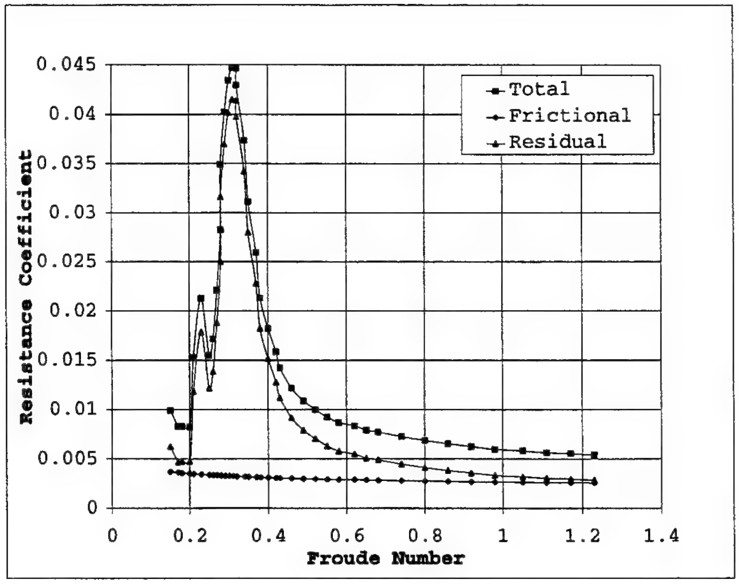

Figure 4.4. ITTC model resistance coefficients versus Froude Number for a single length analysis of the SLICE hull.

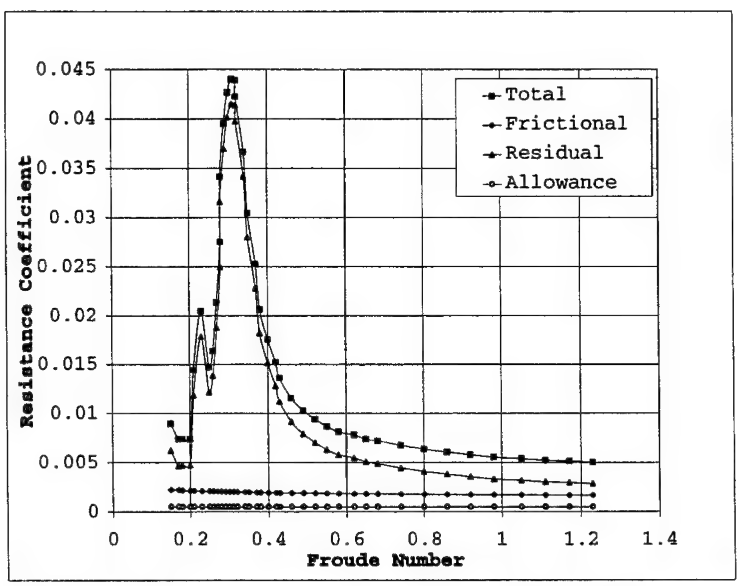

Figure 4.5. ITTC ship resistance coefficients versus Froude Number for a single length analysis of the SLICE hull.

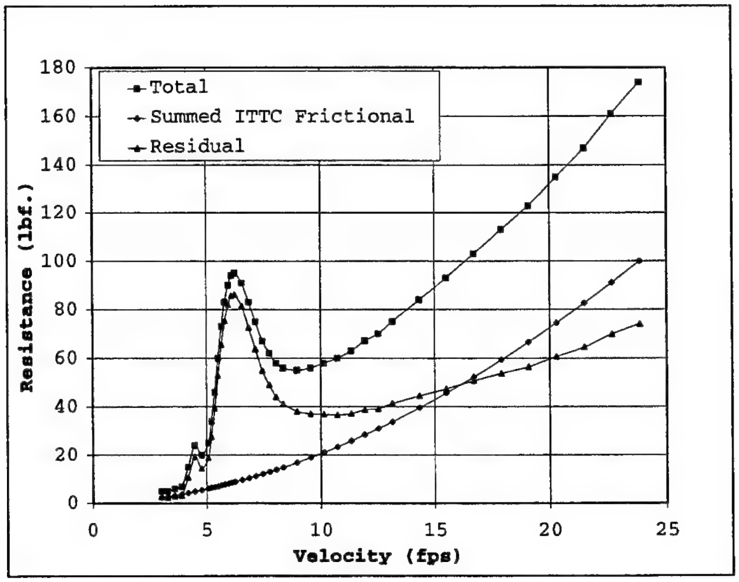

Figure 4.6. ITTC model resistances versus model velocity for the sectionalized SLICE hull.

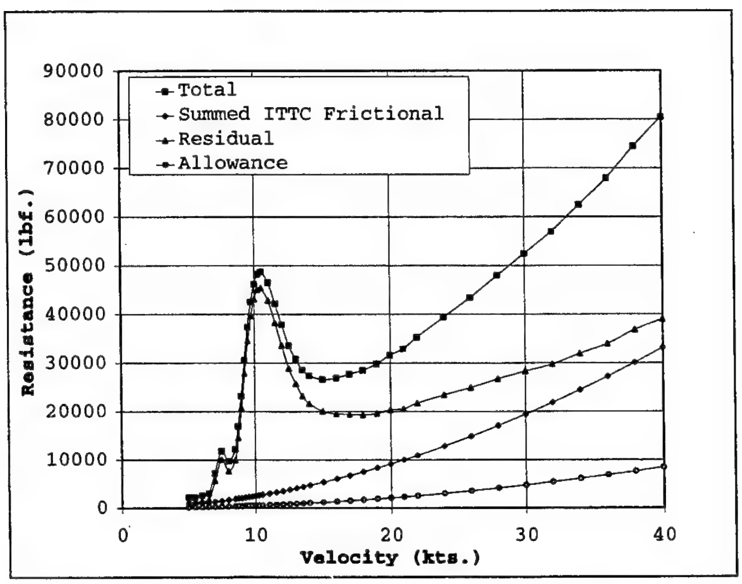

Figure 4.7. ITTC ship resistances versus ship velocity for the sectionalized SLICE hull.

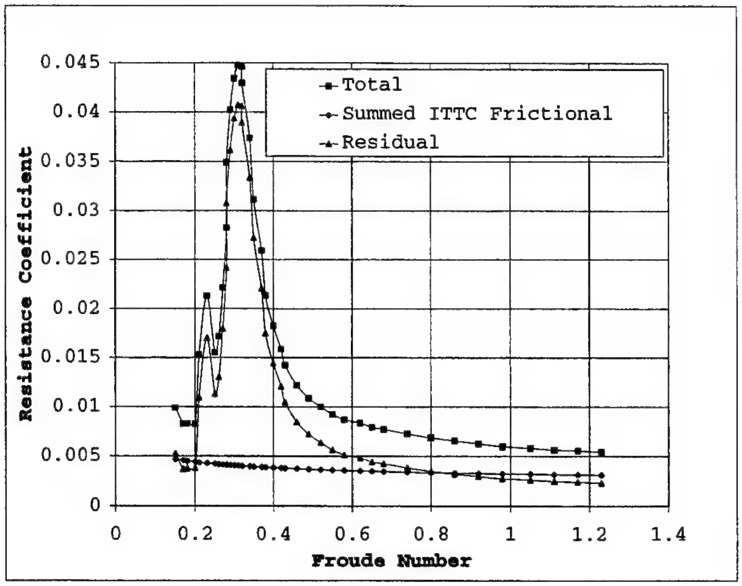

Figure 4.8. ITTC model resistance coefficients versus Froude Number for the sectionalized SLICE hull.

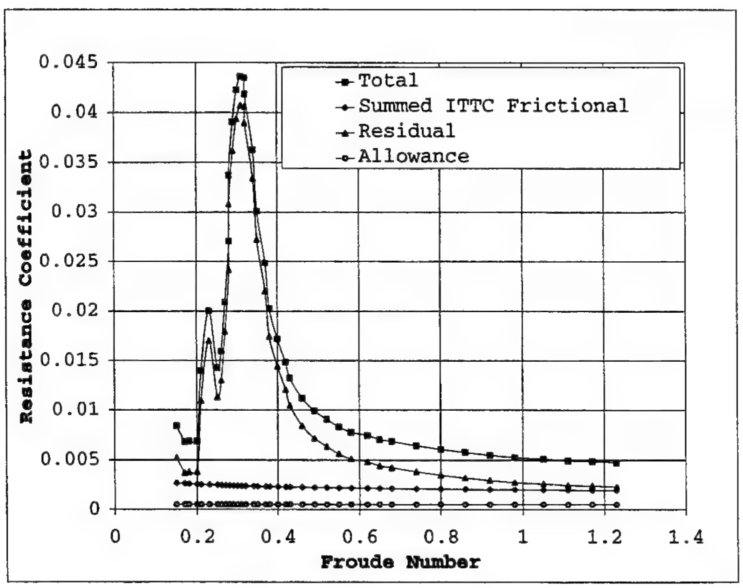

Figure 4.9. ITTC ship resistance coefficients versus Froude Number for the sectionalized SLICE hull.

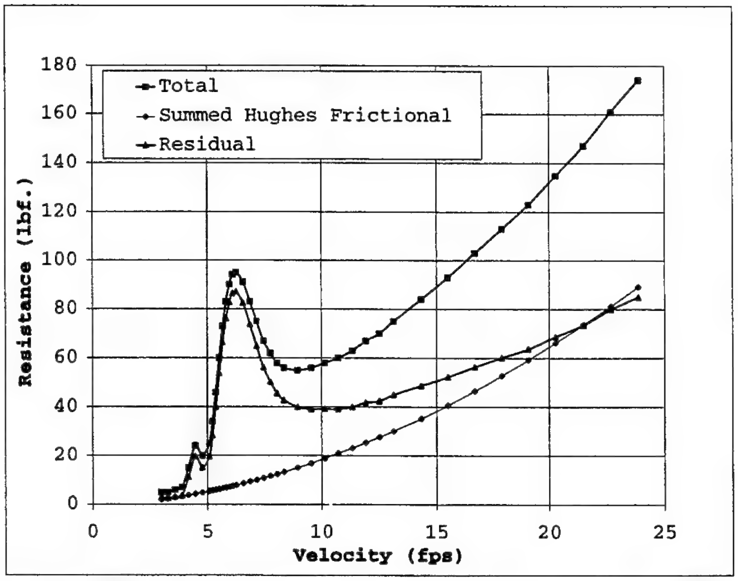

Figure 4.10. Hughes model resistances versus model velocity for the sectionalized SLICE hull.

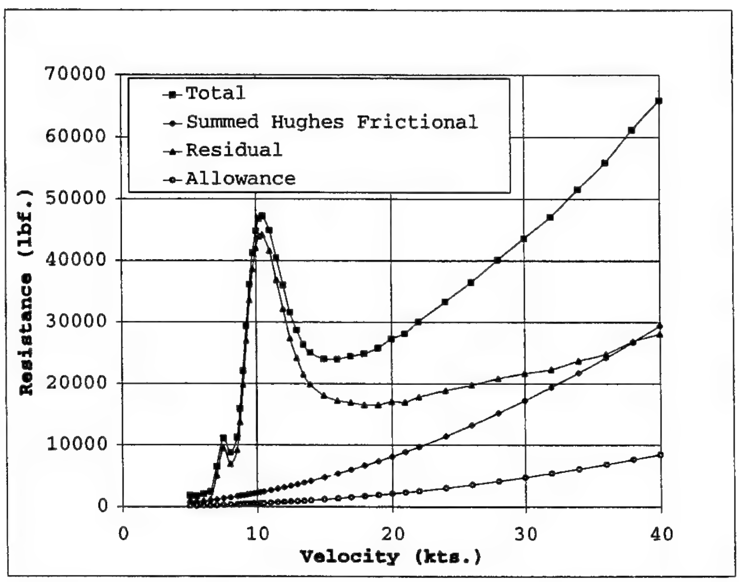

Figure 4.11. Hughes ship resistances versus ship velocity for the sectionalized SLICE hull.

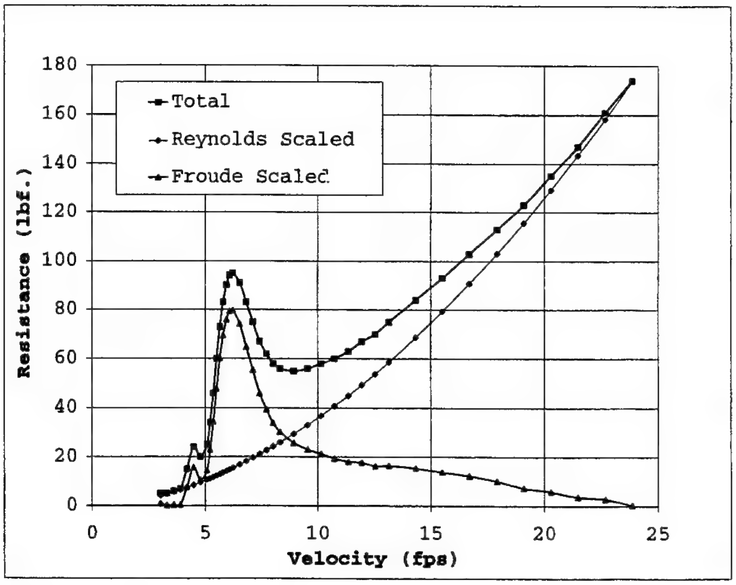

Figure 4.12. Hughes model resistances as functions of Reynolds and Froude Numbers versus model velocity for a sectionalized SLICE hull.

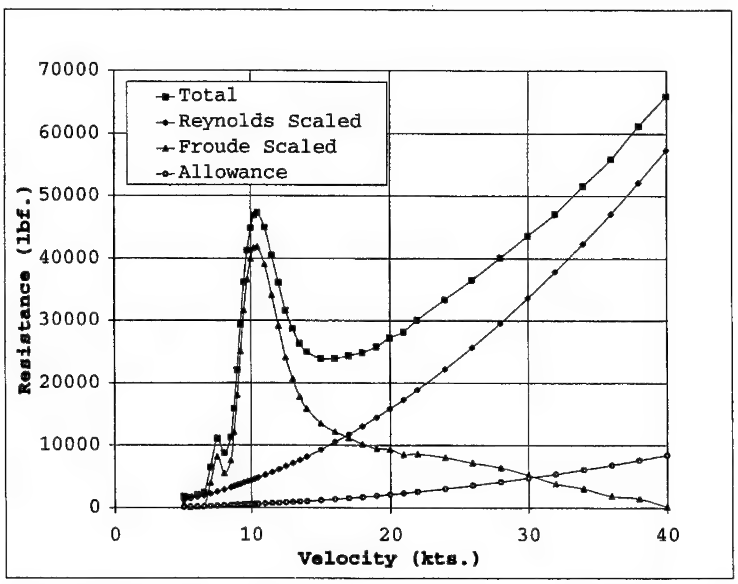

Figure 4.13. Hughes ship resistances as functions of Reynolds and Froude Numbers versus ship velocity for the sectionalized SLICE hull.

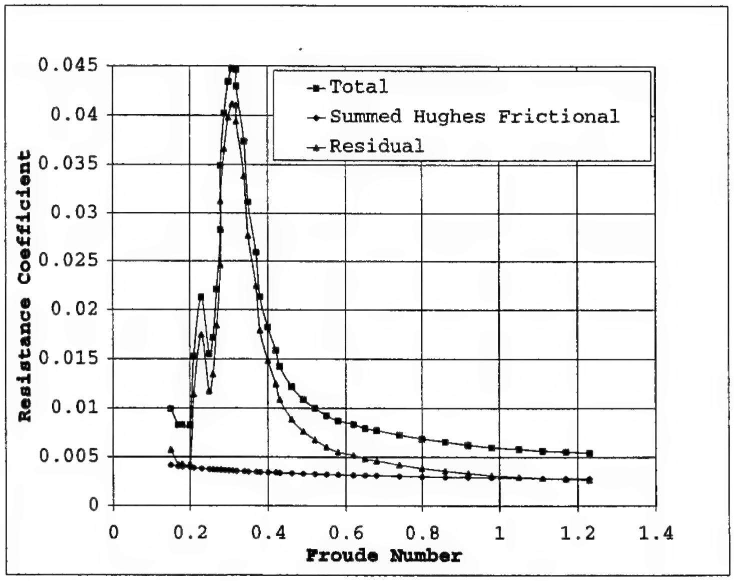

Figure 4.14. Hughes model resistance coefficients versus Froude Number for the sectionalized SLICE hull.

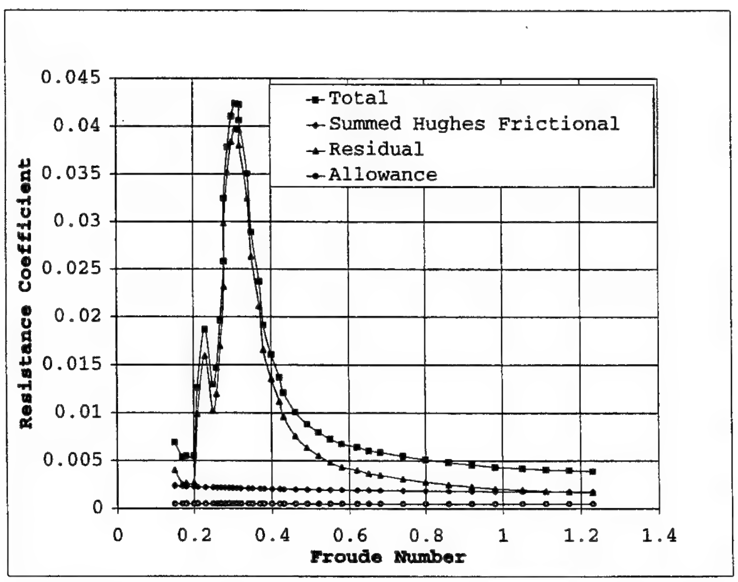

Figure 4.15. Hughes ship resistance coefficients versus Froude Number for the sectionalized SLICE hull.

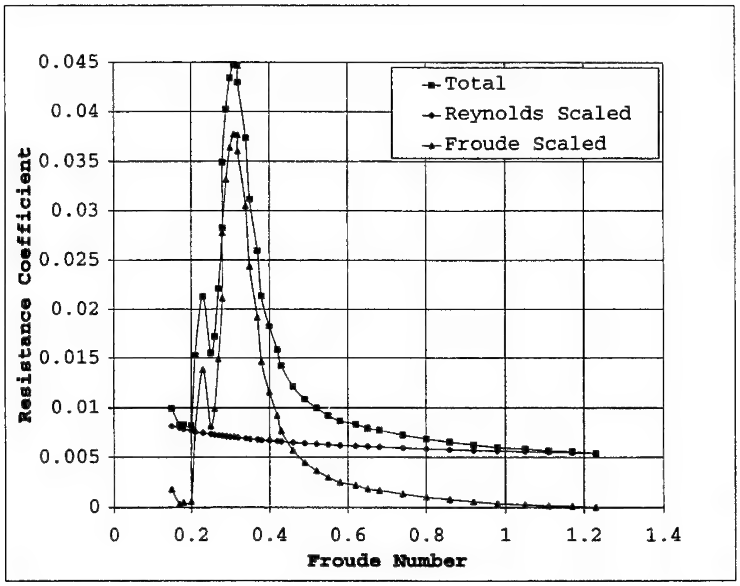

Figure 4.16. Hughes model resistance coefficients as functions of Reynolds and Froude Numbers versus Froude Number for the sectionalized SLICE hull.

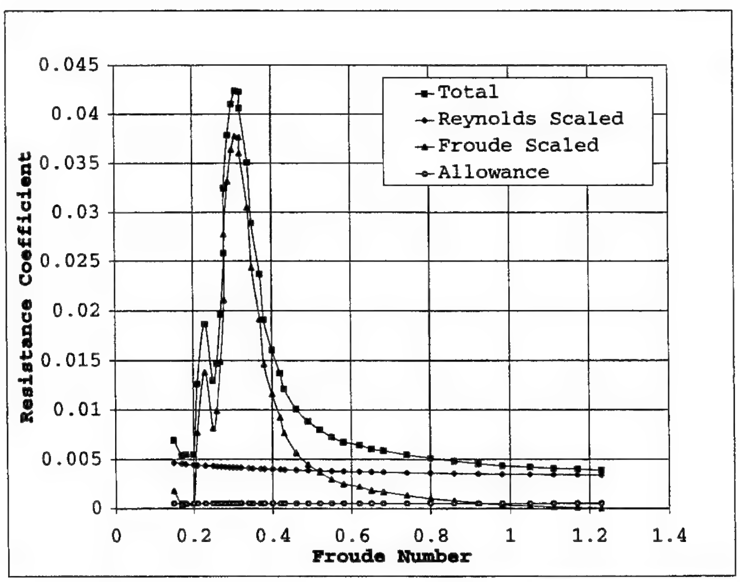

Figure 4.17. Hughes ship resistance coefficients as functions of Reynolds and Froude Numbers versus Froude Number for the sectionalized SLICE hull.

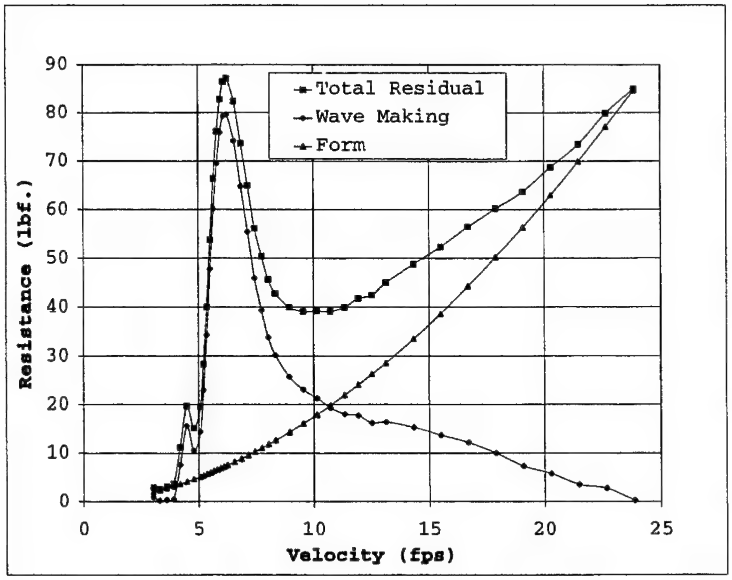

Figure 4.18. Hughes model residual resistances versus model velocity for the sectionalized SLICE hull.

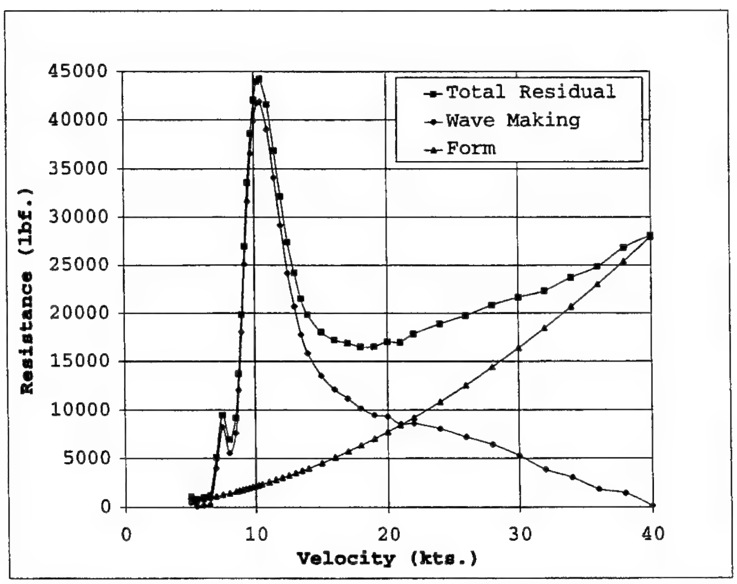

Figure 4.19. Hughes ship residual resistances versus ship velocity for the sectionalized SLICE hull.

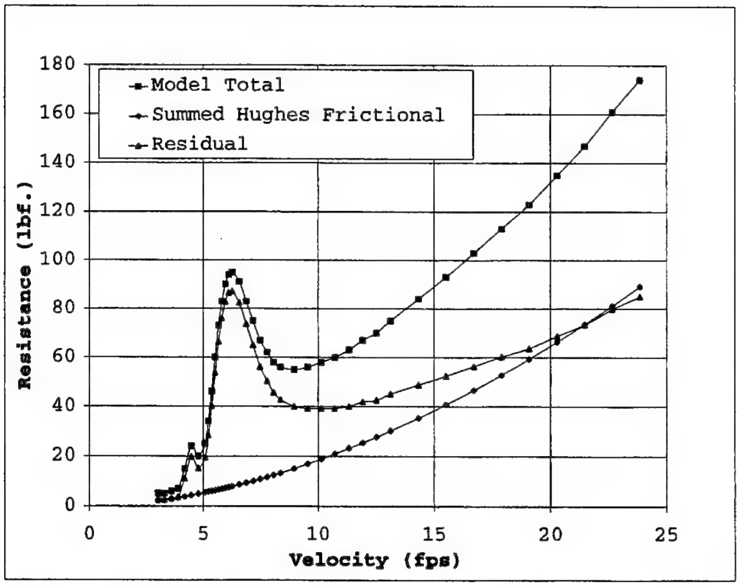

Figure 4.20. Modified Hughes model resistances versus model velocity for the sectionalized SLICE hull.

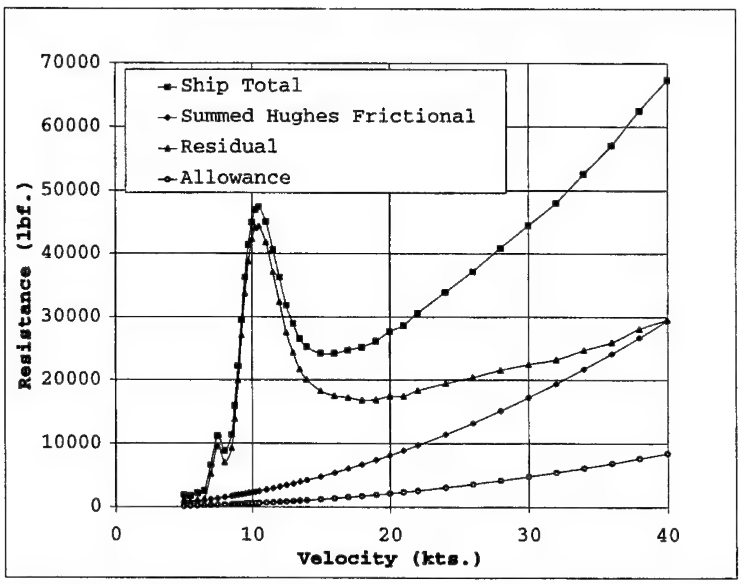

Figure 4.21. Modified Hughes ship resistances versus ship velocity for the sectionalized SLICE hull.

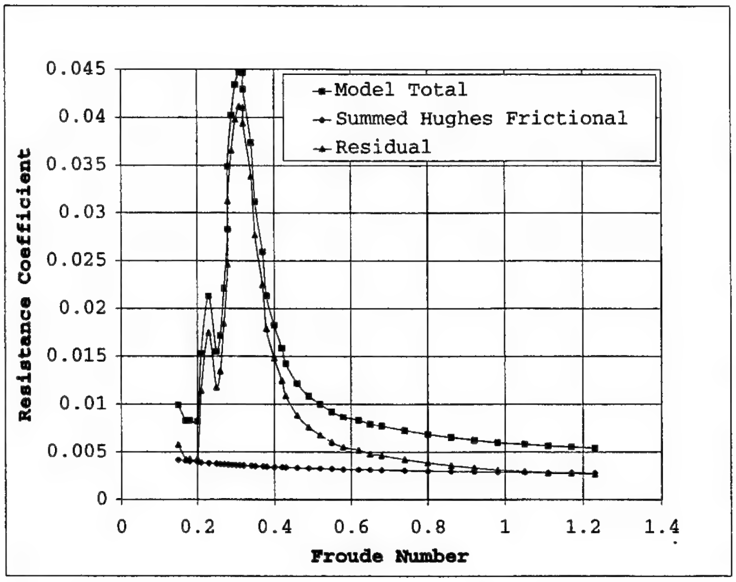

Figure 4.22. Modified Hughes model resistance coefficients versus Froude Number for the sectionalized SLICE hull.

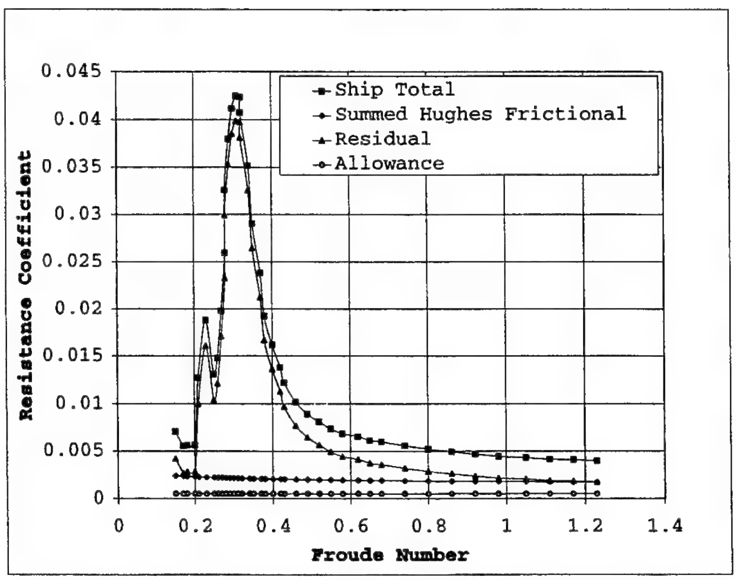

Figure 4.23. Modified Hughes ship resistance coefficients versus Froude Number for the sectionalized SLICE hull.

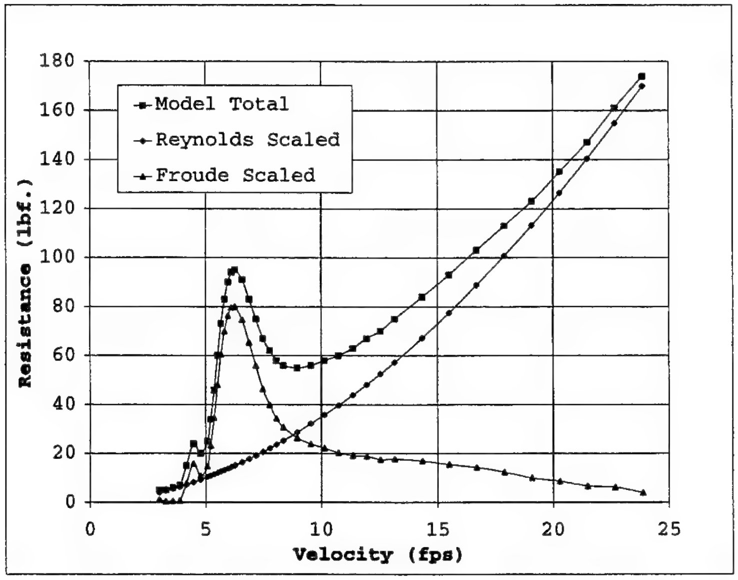

Figure 4.24. Modified Hughes model resistances as functions of Reynolds and Froude Numbers versus model velocity for the sectionalized SLICE hull.

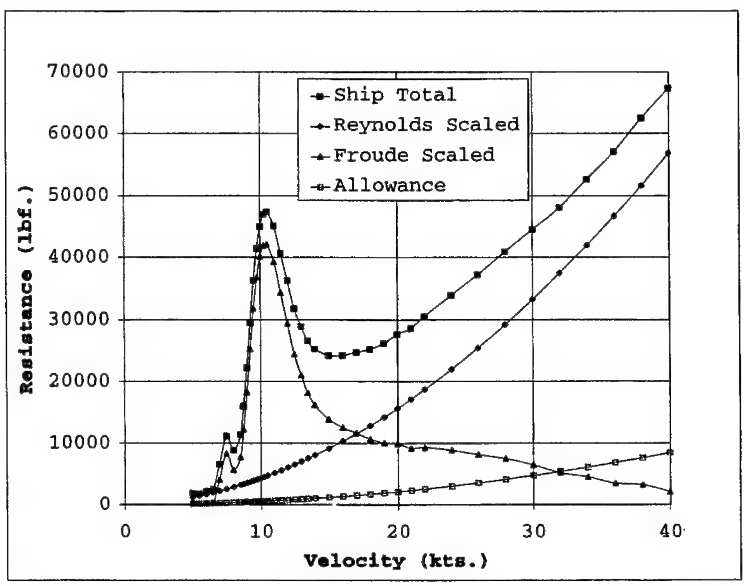

Figure 4.25. Modified Hughes ship resistances as functions of Reynolds and Froude Numbers versus ship velocity for the sectionalized SLICE hull.

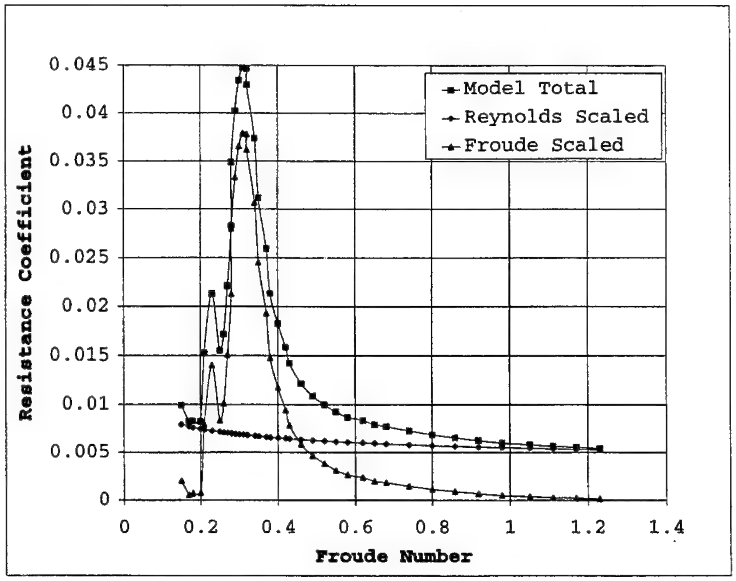

Figure 4.26. Modified Hughes model resistance coefficients as functions of Reynolds and Froude Numbers versus Froude Number for the sectionalized SLICE hull.

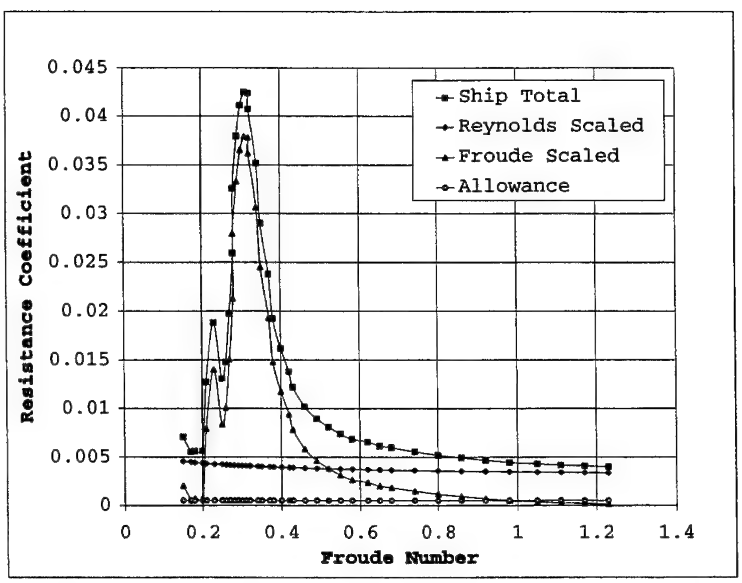

Figure 4.27. Modified Hughes ship resistance coefficients as functions of Reynolds and Froude Numbers versus Froude Number for the sectionalized SLICE hull.

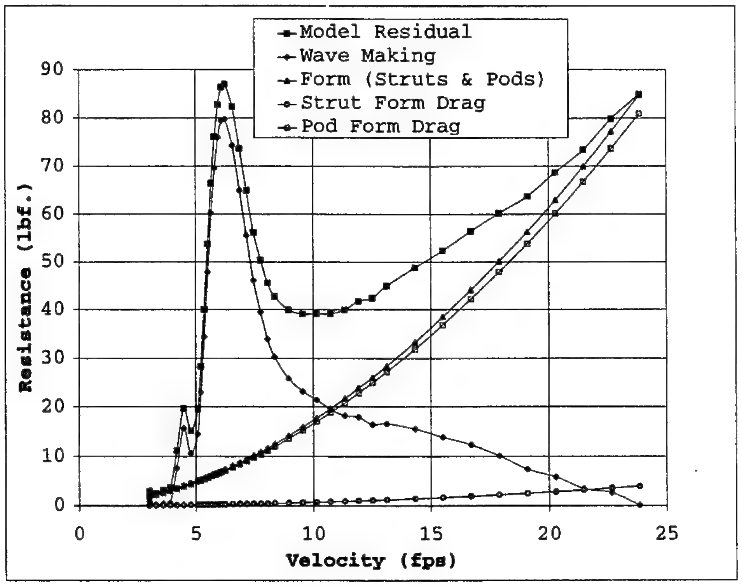

Figure 4.28. Modified Hughes model residual resistances versus model velocity for the sectionalized SLICE hull.

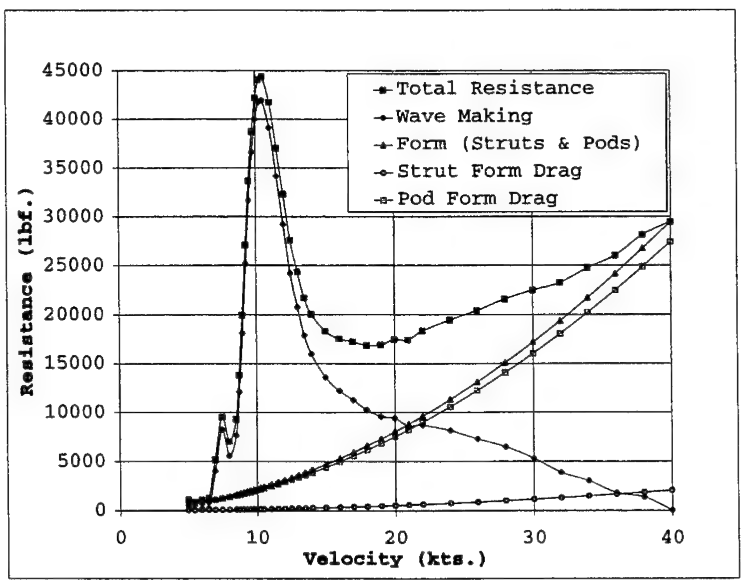

Figure 4.29. Modified Hughes ship residual resistances versus ship velocity for the sectionalized SLICE hull.

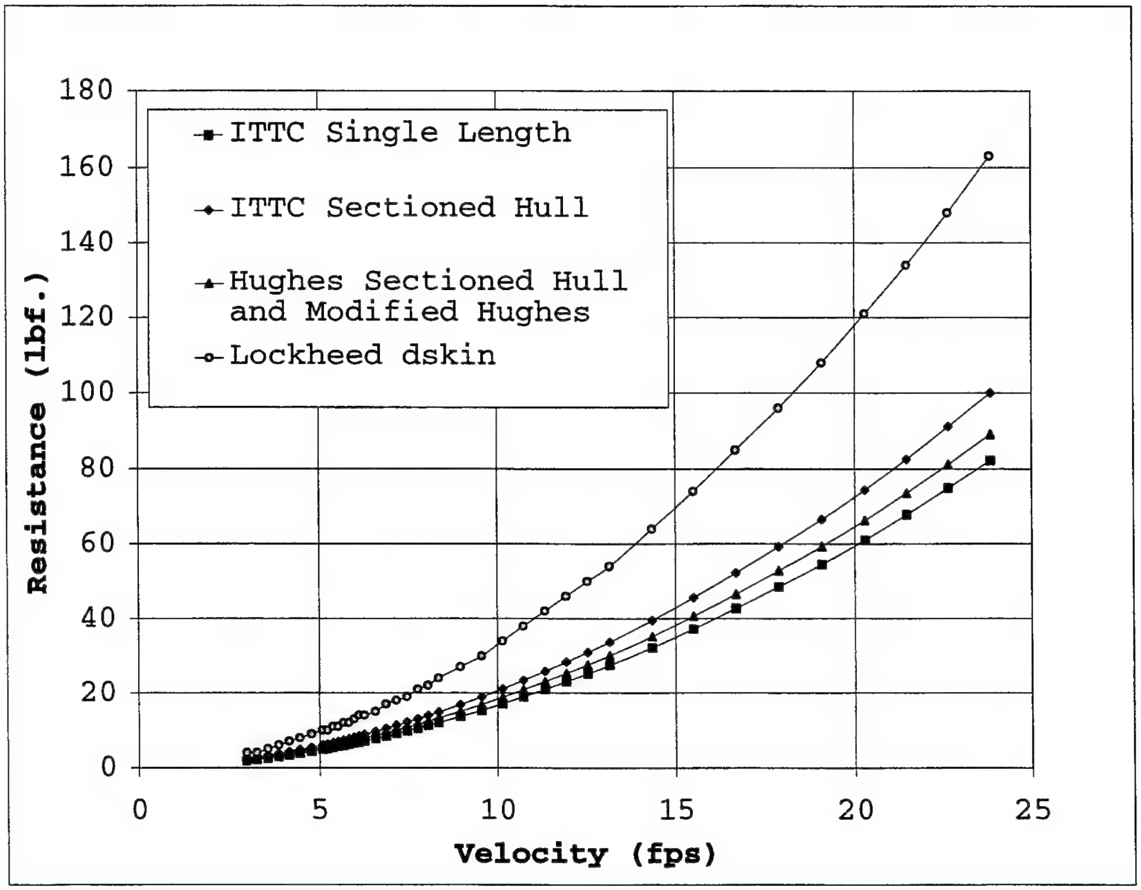

Figure 4.30. Comparison of model frictional resistances.

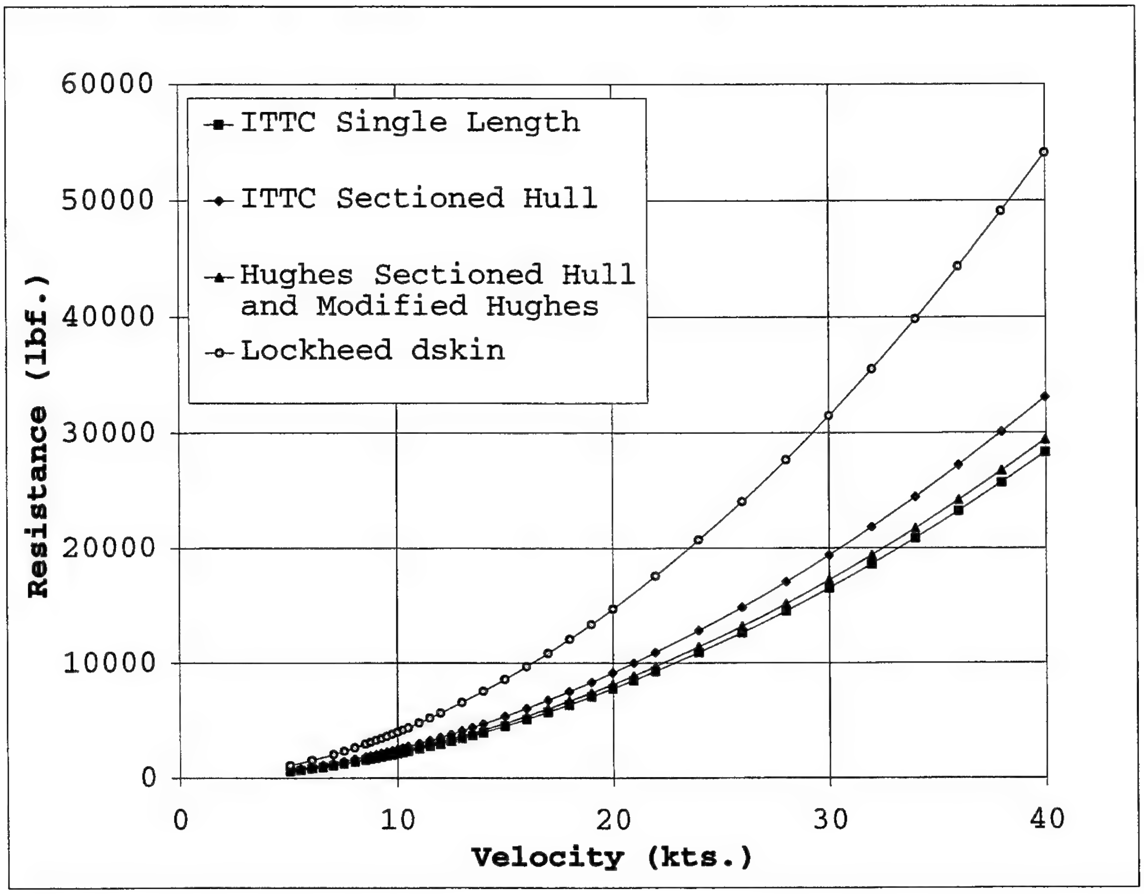

Figure 4.31. Comparison of ship frictional resistances.

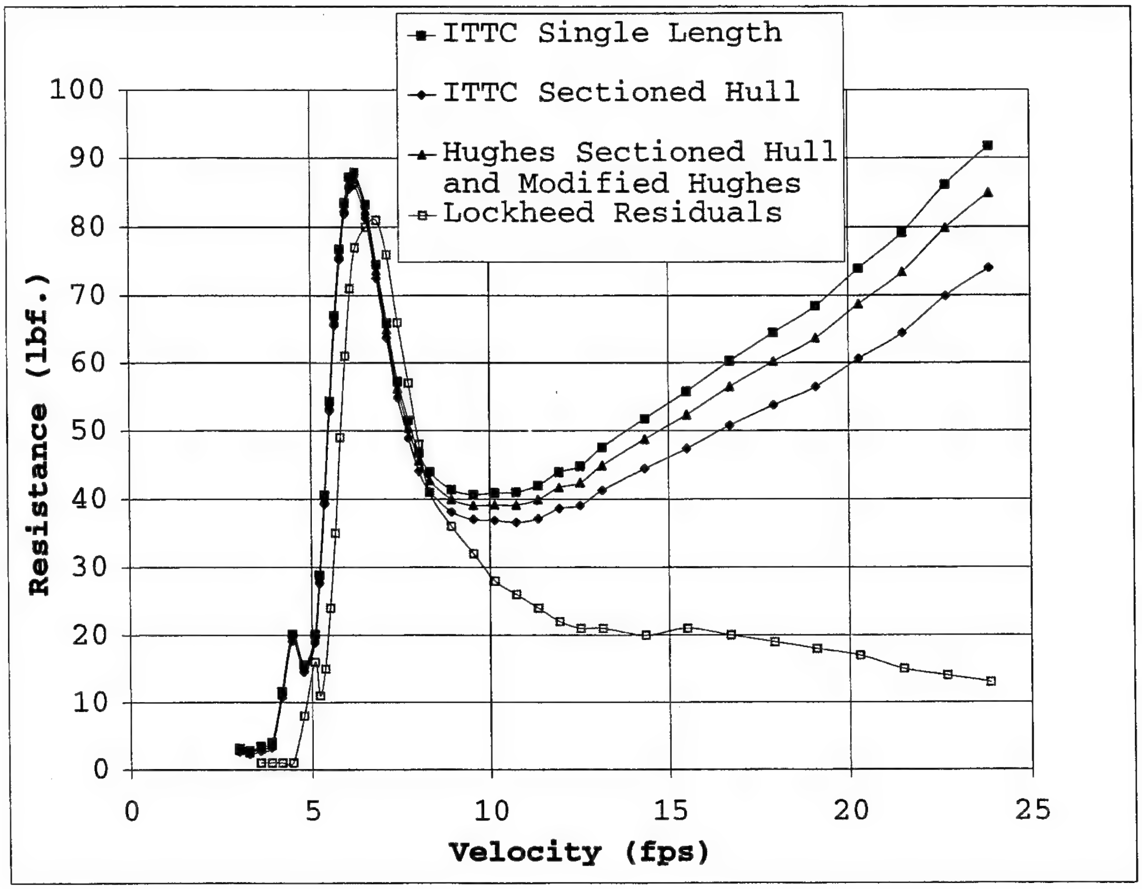

Figure 4.32. Comparison of model residual resistances.

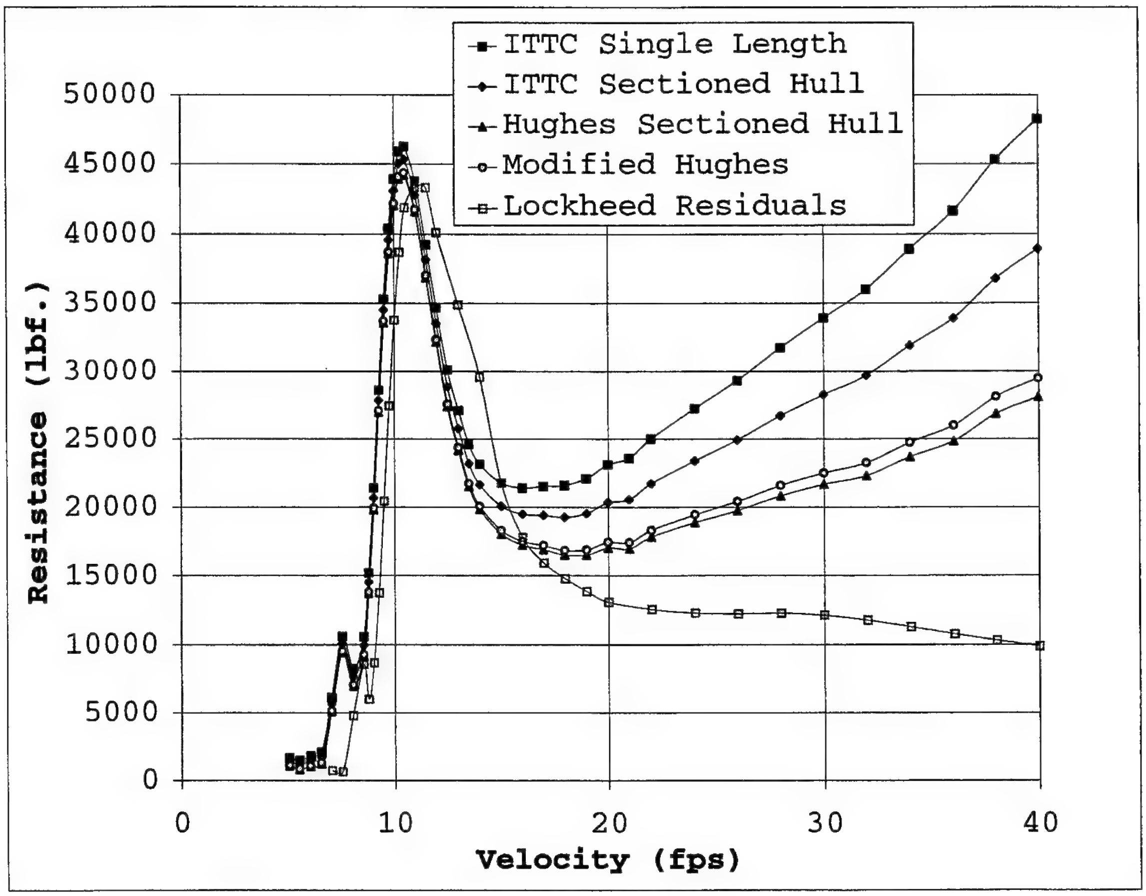

Figure 4.33. Comparison of ship residual resistances.

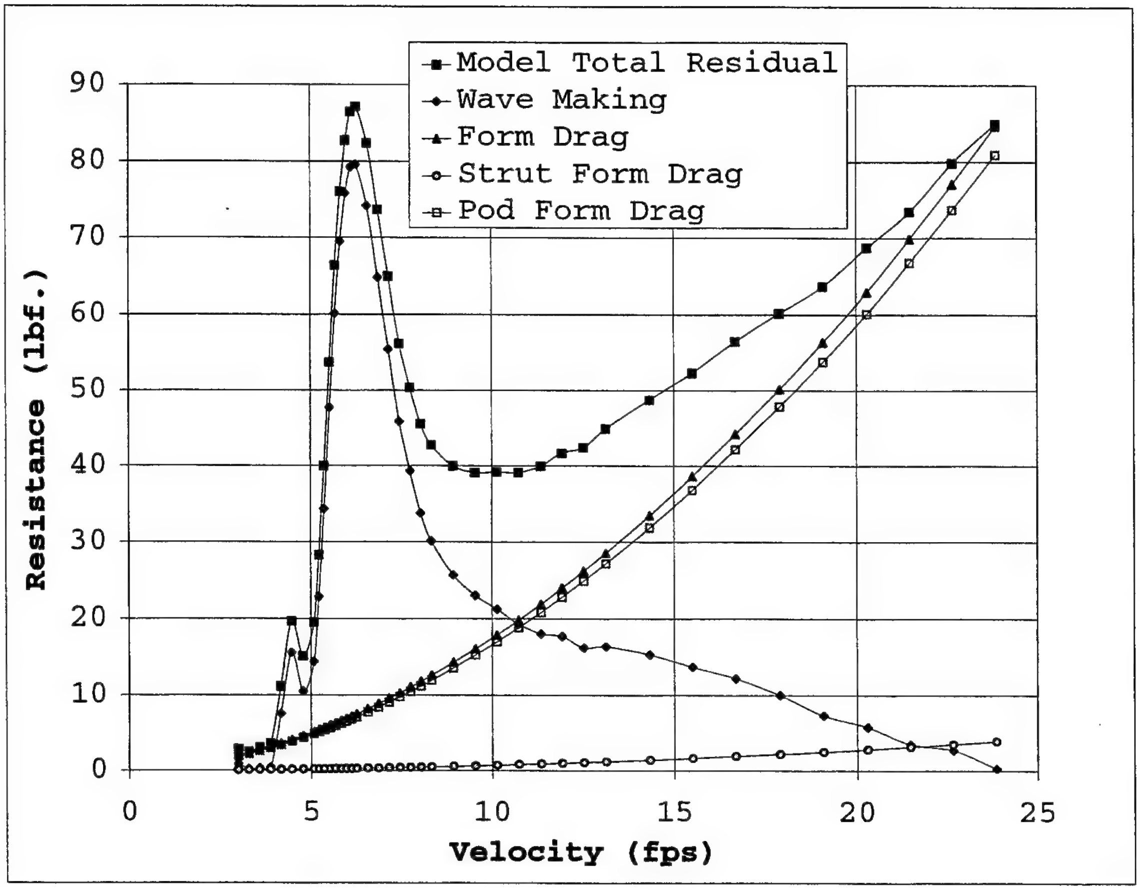

Figure 4.34. Comparison of the model residual resistance division for the Hughes and modified Hughes methods.

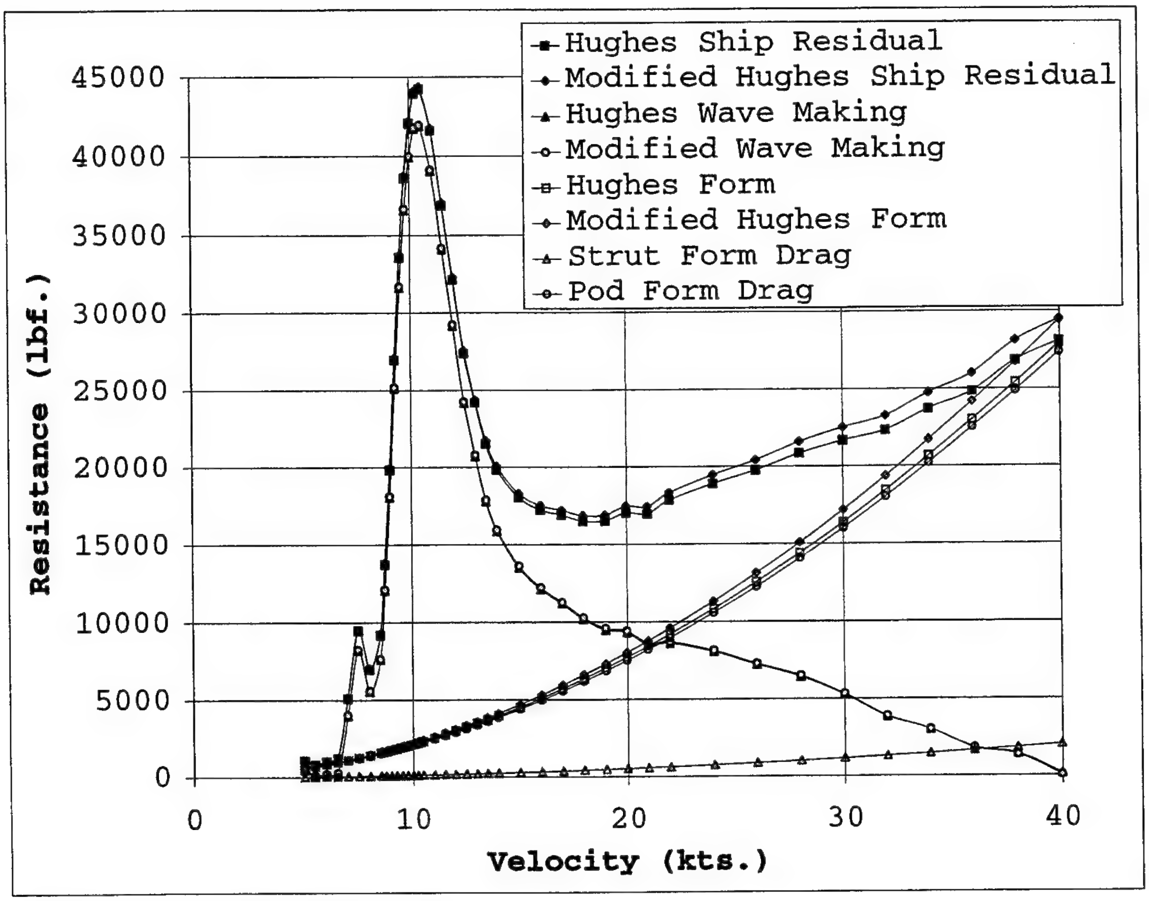

Figure 4.35. Comparison of ship residual resistance division for the Hughes and modified Hughes methods.

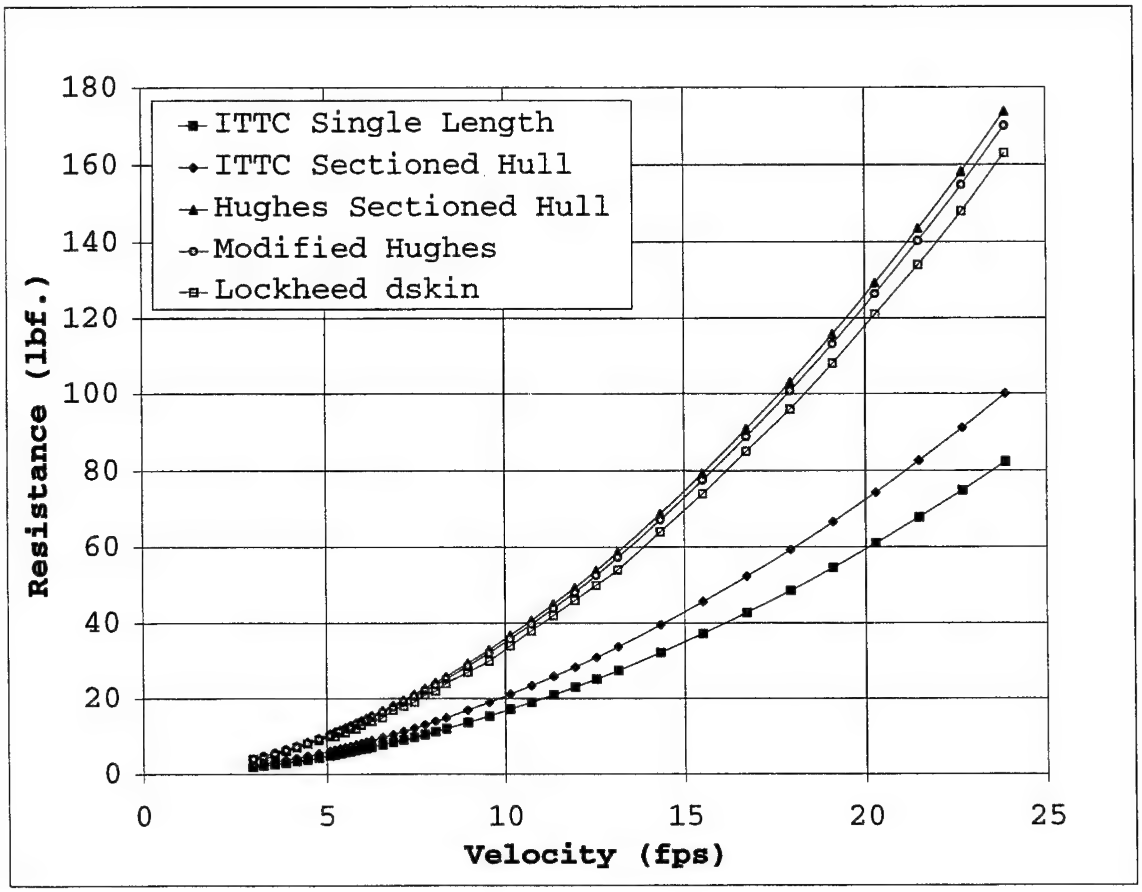

Figure 4.36. Comparison of the Reynolds scaled portion of the model resistance.

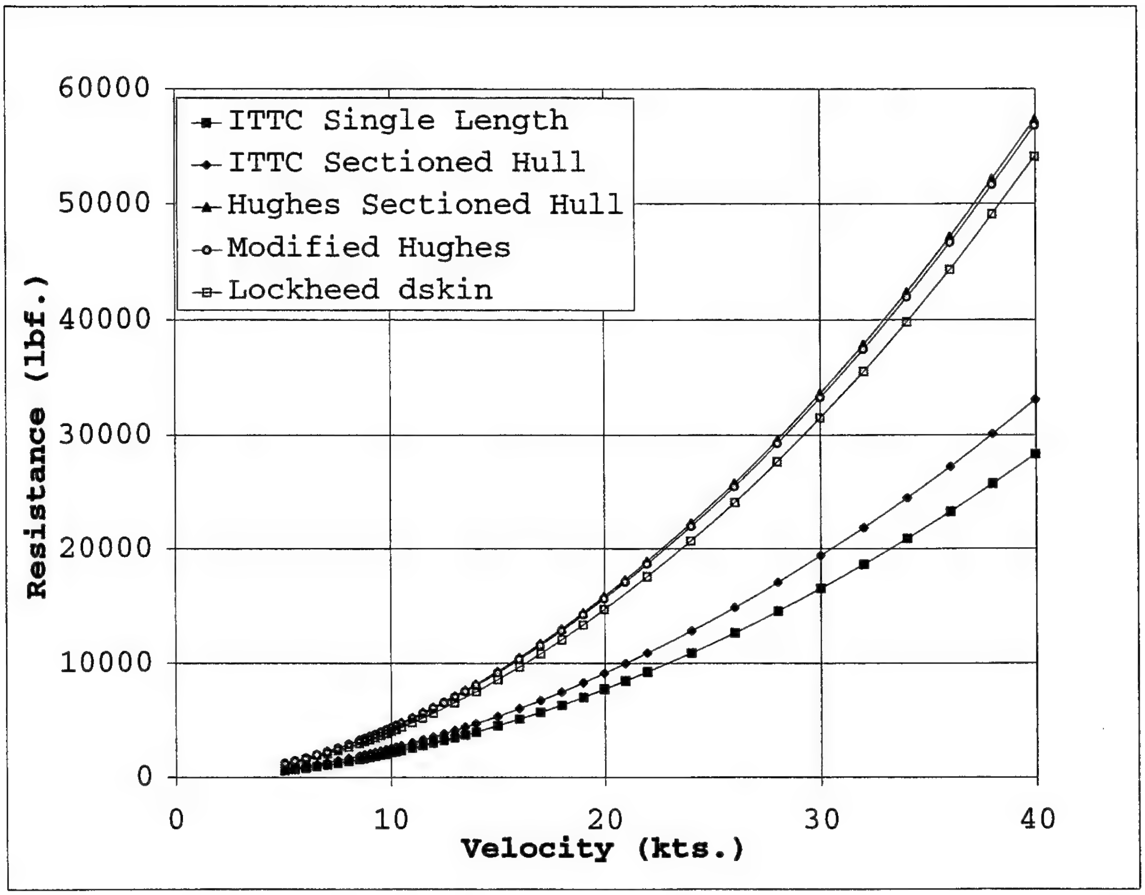

Figure 4.37. Comparison of the ship Reynolds scaled resistances.

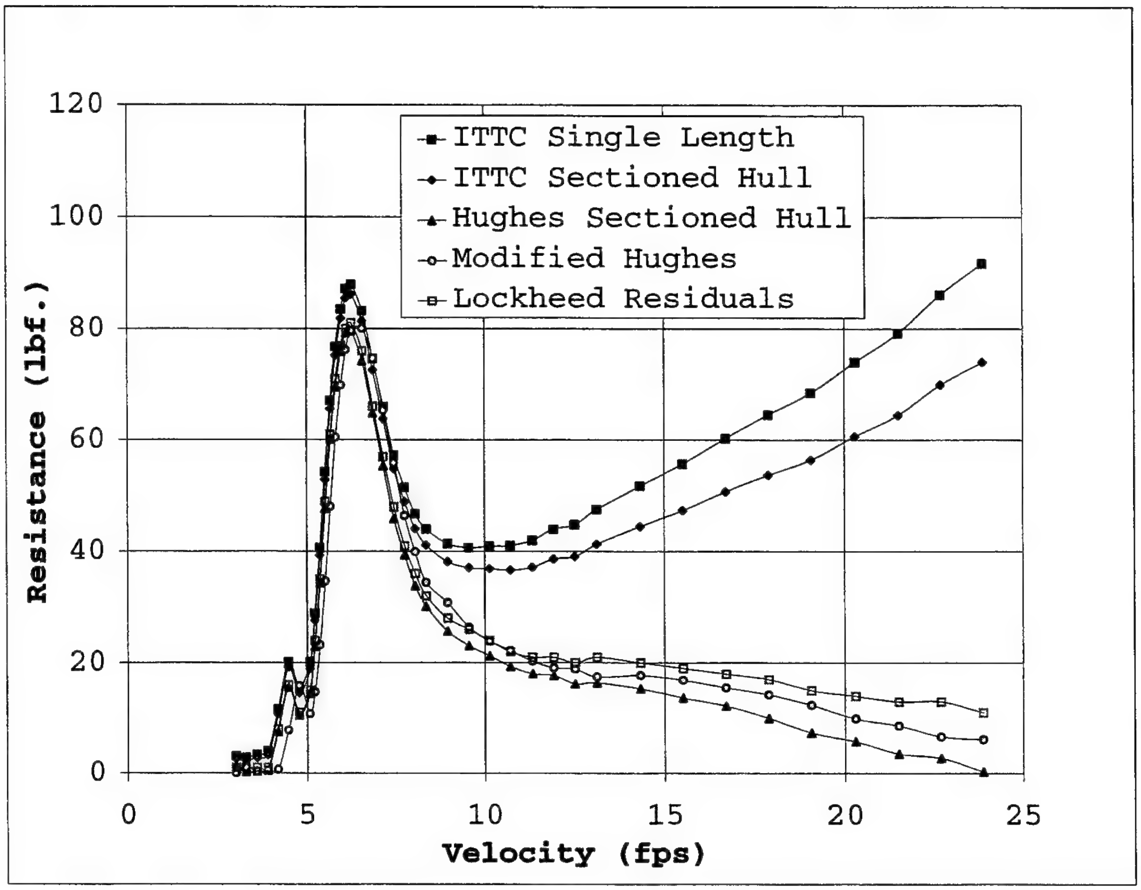

Figure 4.38. Comparison of the Froude scaled portion of the model resistance.

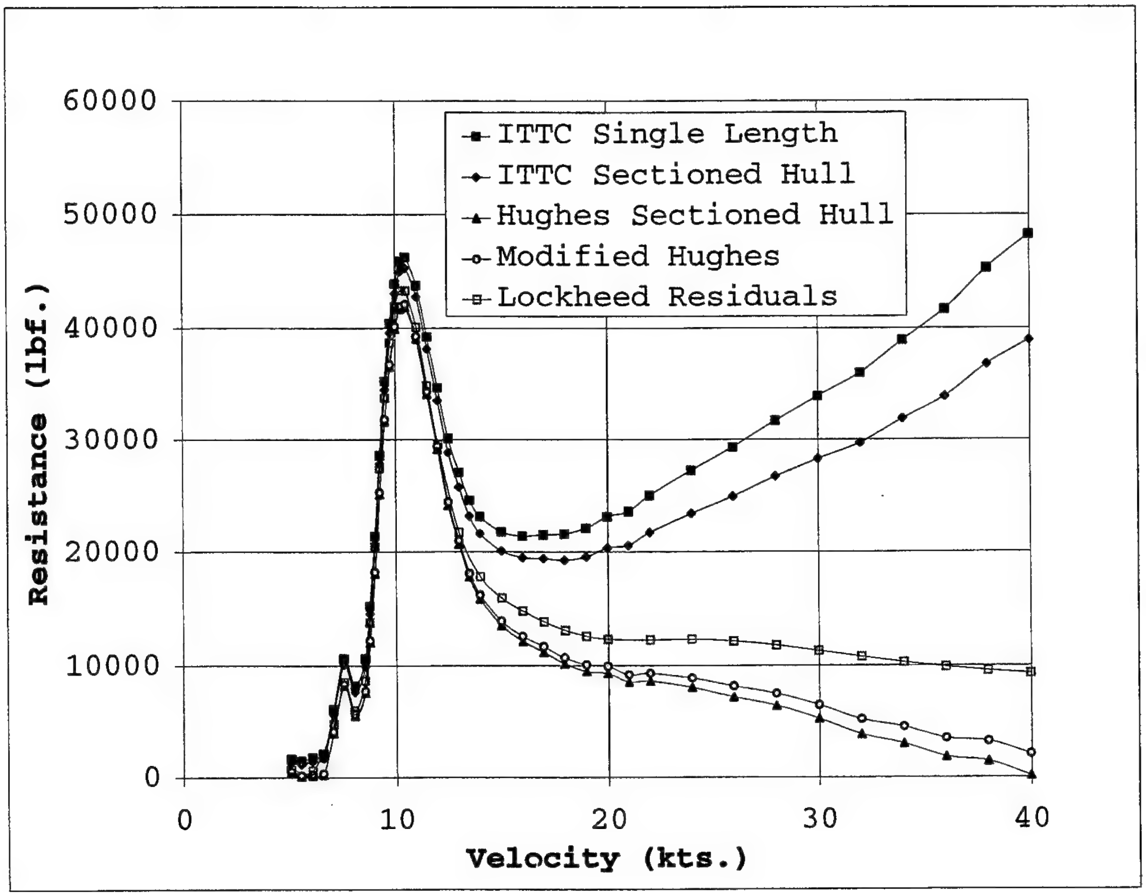

Figure 4.39. Comparison of the ship Froude scaled resistances.

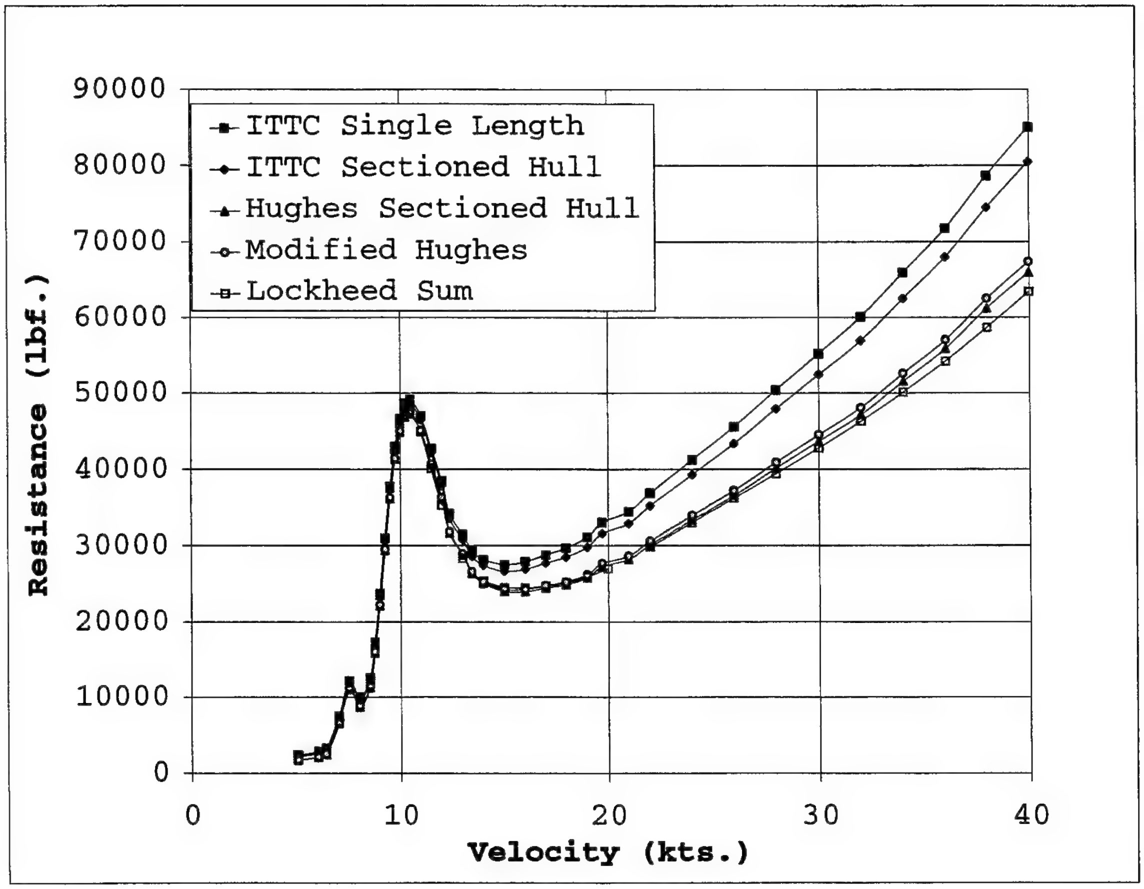

Figure 4.40. Comparison of the ship total resistances.

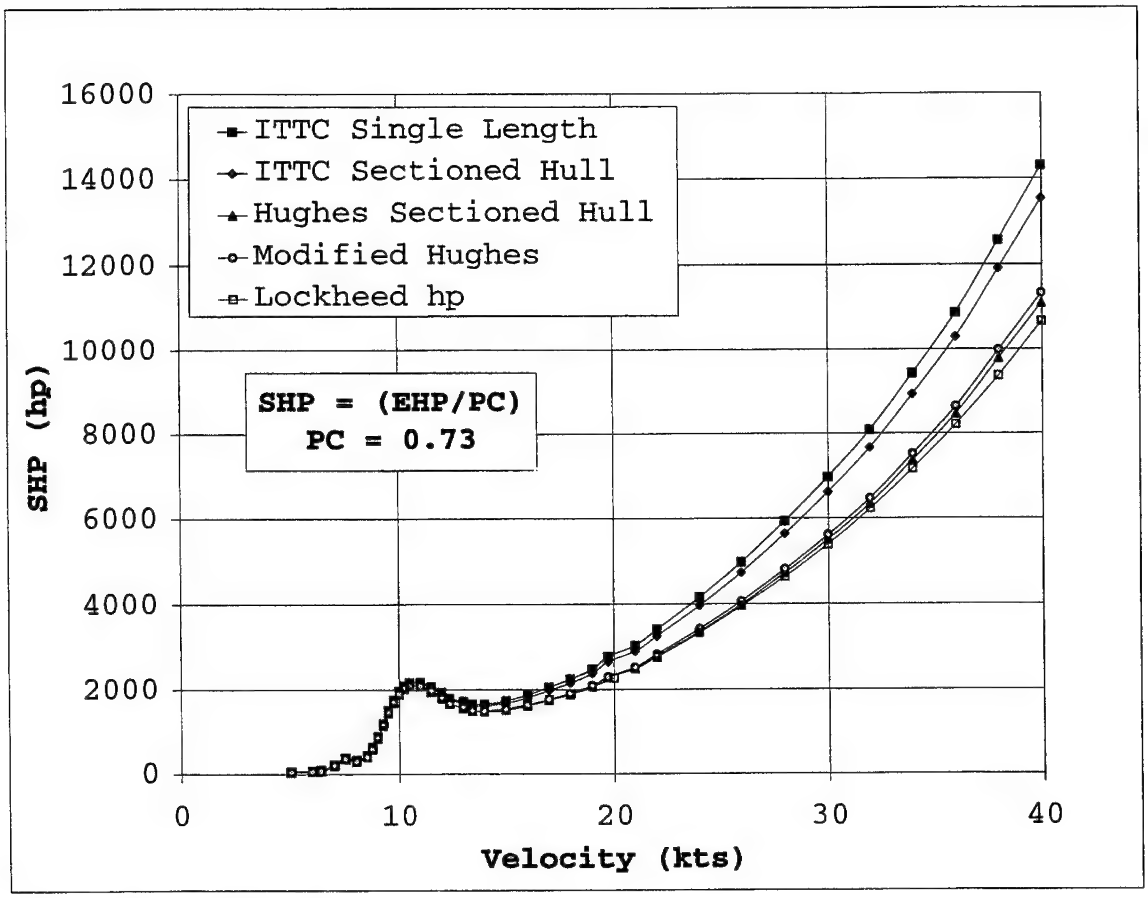

Figure 4.41. Comparison of calculated SHP versus ship velocity.

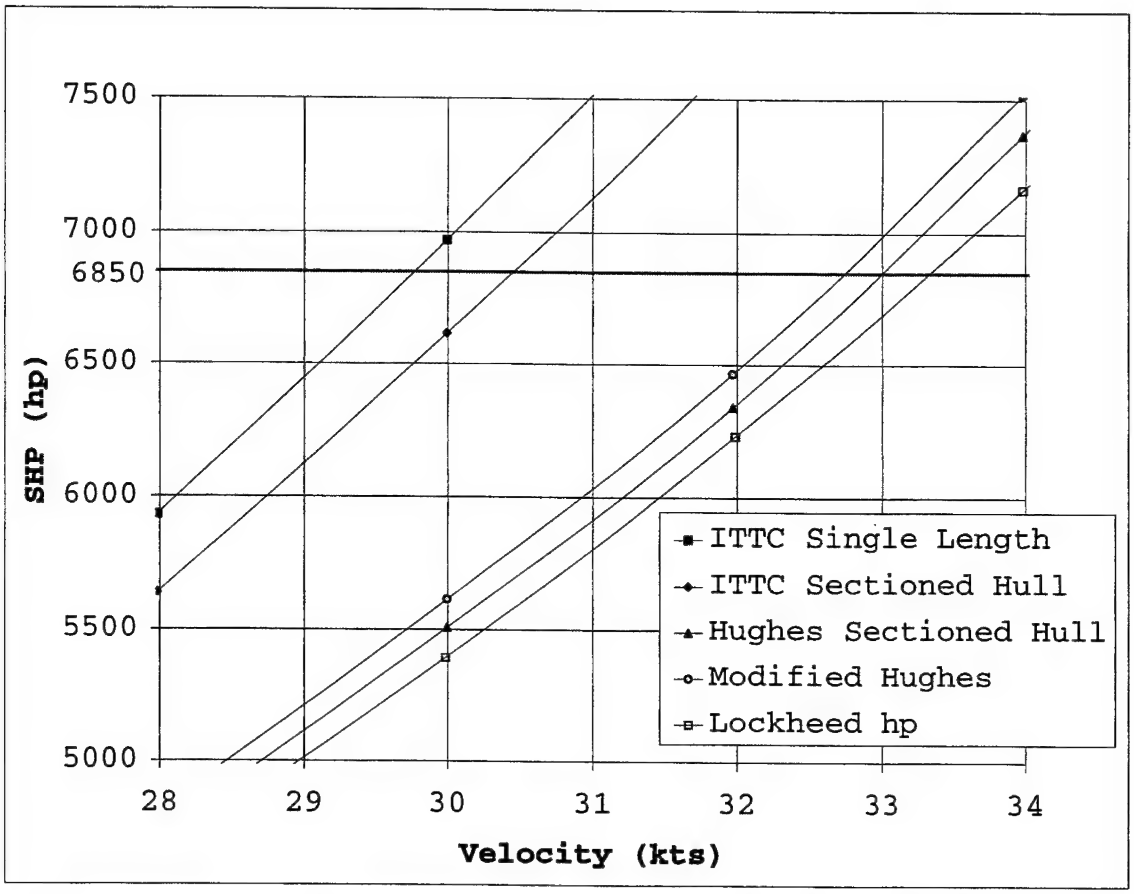

Figure 4.42. Close-up of the SHP curves near 30 knots.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSION

The wetted surface area of the SLICE hull form is radically different from a full displacement monohull and also varies significantly from the SWATH hull. Because of this, standard procedures for predicting ship resistances from model test tank data cannot be used.

The thesis decomposed the total resistance into pod and strut components and further divided these into frictional, form and wave making components. Additionally, the resistances were categorized as functions of the Reynolds and Froude Numbers. The Hughes method provided the means by which the residual resistance was divided into form and wave making components. Ship scaling processes do not usually decompose the form drag, but in the case of the SLICE, two factors lead to a further investigation of the form drag. First, the model had a large form factor which meant that the form drag was almost equal to the frictional resistance. Second, the geometry of the wetted surface area provided a natural separation of the hull for unattached strut and pod analysis.

A large difference between the ITTC and Hughes predictions existed so a modified Hughes method was developed which combined ideas from both processes. In particular, the pod form drag was Reynolds scaled according to the Hughes and the strut form drag was Froude scaled as in the ITTC method. The hybrid procedure examination results fell in between the ITTC and Hughes estimates.

Concerning the design criterion that the ship go at least thirty knots, only the classical ITTC single length determined that the ship required more power. But, as previously stated, the ITTC single length resistance was concluded to be an overestimate. Assuming the propulsive coefficient does not vary much from the designer's value of 0.73, the Hughes and the modified Hughes method predict that thirty knots is achievable.

B. RECOMMENDATIONS FOR FURTHER RESEARCH

Follow-on research should include further investigation of the breakup of the form drag. In particular, a computational fluid dynamic study of the struts and pods as separate entities could be done to validate the modified Hughes method. This analysis might lead to a different division of Reynolds and Froude scaled quantities.

It would be beneficial to include the stabilizers and canards in resistance calculations. This was not done here because the dimensions of these were not known since they were not on the ship drawings. These components would most likely be Reynolds scaled since they are similar to flat plates. Additionally, the effect of varying the angles of the stabilizers and canards could be studied via computational fluid dynamics.

APPENDIX A. WETTED SURFACE AREA CALCULATION

The wetted surface area of the SLICE hull was calculated from the ship drawings (Lockheed, 1994). The waterline was 14 feet. Tables 3 through 10 show the calculations used to determine the surfaces of the submerged hull shown in Figures 3.1 through 3.4. Where separate calculated surface areas overlapped, appropriate area values were subtracted form the total.

Ship Station (ft.)	Drawings Vertical Height (1/32 ")	Ship Vertical Height (ft.)	Horizontal Distance From Strut CL (ft.)	Ship Surface Chord (ft.)	Simpson Rule Multiplier	Simpson Weighted Chord (ft.)	Simpson Rule Sums	Ship Surface Area (ft.^2)	Trapezoid Strip Area (ft.^2)
-7.45	0	0	0.00	0.00					
-7.00	2	0.25	0.06	0.26	1	0.26		0.06	0.06
-6.00	6	0.75	0.21	0.78	4	3.11			0.52
-5.00	10	1.25	0.35	1.30	2	2.60			1.04
-4.00	15	1.875	0.49	1.94	4	7.75	Simpson		1.62
-3.00	20	2.5	0.63	2.58	2	5.16	1/3 rd.		2.26
-2.00	24	3	0.78	3.10	4	12.39	sum		2.84
-1.00	28	3.5	0.92	3.62	1	3.62	34.89	11.63	3.36
0.00	32	4	1.06	4.14	1	4.14		3.88	3.88
0.50	14	1.75	0.07	1.75	4	7.01			1.47
1.00	8	1	0.07	1.00	2	2.01			0.69
1.50	4	0.5	0.07	0.51	4	2.02	Simpson		0.38
2.00	3	0.375	0.07	0.38	2	0.76	1/3 rd.		0.22
2.50	1.5	0.1875	0.07	0.20	4	0.80	sum		0.15
3.00	0	0	0.00	0.00	1	0.00	16.73	2.79	0.05
				Total Area of AREA 1 (One Side) =				18.36	
				Trapezoidal Strip Area Comparison ------------					18.52

Table 3. Calculation of Wetted Surface Area One.

Ship Station	Drawings Vertical Height	Ship Vertical Height	Horizontal Distance From Strut CL	Ship Surface Chord	Simpson Rule Multiplier	Simpson Weighted Chord	Simpson Rule Sums	Ship Surface Area	Trapezoid Strip Area
(ft.)	(1/32 ")	(ft.)	(ft.)	(ft.^2)		(ft.)		(ft.^2)	(ft.^2)
50.00	0	0	0.00	0.00					
57.80	32	4	1.11	4.15				16.19	16.19
58.00	16	2	1.14	2.30	1	2.30		0.65	0.65
58.50	9	1.125	1.21	1.65	4	6.61	Simpson		0.99
59.00	5	0.625	1.28	1.43	2	2.85	1/3 rd.		0.77
59.50	3	0.375	1.35	1.40	4	5.61	sum		0.71
60.00	2	0.25	1.42	1.45	1	1.45	18.82	3.14	0.71
60.67	0	0	0.00	0.00				0.48	0.48
				Total Area of AREA 2 (One Side) =				19.97	
				Trapezoidal Strip Area Check ----------------					20.49

Table 4. Calculation of Wetted Surface Area Two.

Ship Station	Drawings Depth	Ship Vertical Depth	Simpson Rule Multiplier	Simpson Weight Chord	Simpson Rule Sums	Ship Surface Area	Trapezoid Strip Area
	(1/4" = 1')						
(ft.)	(1/32 ")	(ft.)		(ft.)	(ft.)	(ft.^2)	(ft.^2)
0.00	48	6.00	1	6.00			
0.50	50	6.25	4	25.00			3.06
1.00	50	6.25	2	12.50			3.13
1.50	51	6.38	4	25.50	Simpson		3.16
2.00	49	6.13	2	12.25	1/3 rd.		3.13
2.50	47	5.88	4	23.50	sum		3.00
3.00	47	5.88	1	5.88	110.63	18.44	2.94
4.00	43	5.38	4	21.50	Simpson		5.63
5.00	41	5.13	2	10.25	1/3 rd.		5.25
6.00	39	4.88	4	19.50	sum		5.00
7.00	38	4.75	1	4.75	61.88	20.63	4.81
17.00	38	4.75				47.50	47.50
24.00	57	7.13				41.56	41.56
		Total Area of AREA 3 (One Side)=				128.13	
		Trapezoidal Strip Area check ----------------					128.16

Table 5. Calculation of Wetted Surface Area Three.

Ship	Drawings	Ship	Simpson	Simpson	Simpson	Ship	Trapezoid
Station	Vertical	Vertical	Rule	Weight	Chord	Surface	Strip
	(1/4 " = 1')	Depth	Multiplier	Chord	Sums	Area	Area
(ft.)	(1/32 ")	(ft.)		(ft.)	(ft.)	(ft.^2)	(ft.^2)
57.67	16	2.00					
58.00	31	3.88	1	3.88		0.98	0.98
58.50	36	4.50	4	18.00	Simpson		2.09
59.00	40	5.00	2	10.00	1/3 rd.		2.38
59.50	38	4.75	4	19.00	sum		2.44
60.00	41	5.13	1	5.13	56.00	9.33	2.47
60.67	40	5.00				3.38	3.38
61.00	38	4.75	1	4.75		1.62	1.62
62.00	38	4.75	4	19.00			4.75
63.00	38	4.75	2	9.50			4.75
64.00	38	4.75	4	19.00			4.75
65.00	38	4.75	2	9.50			4.75
66.00	38	4.75	4	19.00			4.75
67.00	40	5.00	2	10.00			4.88
68.00	42	5.25	4	21.00			5.13
69.00	45	5.63	2	11.25			5.44
70.00	48	6.00	4	24.00			5.81
71.00	51	6.38	2	12.75			6.19
72.00	53	6.63	4	26.50			6.50
73.00	55	6.88	2	13.75			6.75
74.00	57	7.13	4	28.50			7.00
75.00	59	7.38	2	14.75			7.25
76.00	61	7.63	4	30.50			7.50
77.00	62	7.75	2	15.50			7.69
78.00	63	7.88	4	31.50	Simpson		7.81
79.00	65	8.13	2	16.25	1/3 rd.		8.00
80.00	67	8.38	4	33.50	sum		8.25
81.00	69	8.63	1	8.63	379.13	126.38	8.50
81.67	71	8.88				5.83	5.83
		Total Area of AREA 4 (One Side) =				147.52	
		Trapezoidal Strip Area check ------------------					147.63

Table 6. Calculation of Wetted Surface Area Four.

Ship Station (ft.)	Point "A" coords X (inch)	Point "A" coords Y (inch)	Point "B" coords X (inch)	Point "B" coords Y (inch)	Ship Chord |AB| (ft.)	Simpson Rule Multiplier	Simpson Weight Chord (ft.)	Simpson Rule Sums (ft.)	Ship Surface Area (ft.^2)	Trapezoid Strip Area (ft.^2)
0.00	0.00	0.00	0.00	0.00	0.00					
0.13	8.76	5.06	5.18	11.26	0.60				0.04	0.04
0.25	12.25	7.07	6.10	17.74	1.03				0.10	0.10
0.50	16.94	9.78	8.12	25.05	1.47	1	1.47		0.31	0.31
1.00	22.50	12.99	11.36	32.29	1.86	4	7.43			0.83
1.50	27.36	15.80	13.66	39.54	2.28	2	4.57			1.04
2.00	30.23	17.45	15.68	42.65	2.42	4	9.70			1.18
2.50	33.09	19.10	16.95	47.06	2.69	2	5.38			1.28
3.00	35.08	20.25	17.84	50.11	2.87	4	11.49			1.39
3.50	36.75	21.22	18.42	52.97	3.06	2	6.11			1.48
4.00	38.35	22.14	18.95	55.74	3.23	4	12.93	Simpson		1.57
4.50	39.19	22.63	19.22	57.21	3.33	2	6.66	1/3 rd.		1.64
5.00	40.03	23.11	19.50	58.67	3.42	4	13.69	sum		1.69
5.50	40.81	23.56	19.50	60.48	3.55	1	3.55	82.98	13.83	1.74
6.00	41.14	23.75	19.50	61.24	3.61				1.79	1.79
6.65	41.57	24.00	19.50	62.23	3.68				2.37	2.37
7.75	41.57	24.00	21.11	59.44	3.41				3.90	3.90
8.00	41.57	24.00	21.11	59.44	3 41	1	3.41		0.85	0.85
8.50	41.57	24.00	21.11	59.44	3.41	4	13.64			1.71
9.00	41.57	24.00	21.11	59.44	3.41	2	6.82			1.71
9.50	41.57	24.00	21.11	59.44	3.41	4	13.64			1.71
10.00	41.57	24.00	21.11	59.44	3.41	2	6.82			1.71
10.50	41.57	24.00	21.11	59.44	3.41	4	13.64			1.71
11.00	41.57	24.00	21.11	59.44	3.41	2	6.82			1.71
11.50	41.57	24.00	21.11	59.44	3.41	4	13.64			1.71
12.00	41.57	24.00	21.11	59.44	3.41	2	6.82			1.71
12.50	41.57	24.00	21.11	59.44	3.41	4	13.64	Simpson		1.71
13.00	41.57	24.00	21.11	59.44	3.41	2	6.82	1/3 rd.		1.71
13.50	41.57	24.00	21.11	59.44	3.41	4	13.64	sum		1.71
14.00	38.68	28.43	20.77	59.44	2.98	1	2.98	122.34	20.39	1.60
15.00	35.04	32.80	19.67	59.44	2.56				2.77	2.77
16.00	32.46	35.36	18.56	59.44	2.32				2.44	2.44
16.37	31.19	36.49	17.94	59.44	2.21				0.84	0.84
17.00	29.96	36.91	15.35	62.23	2.44				1.46	1.46
18.00	25.08	39.50	13.57	59.43	1.92	1	1.92		2.18	2.18
19.00	19.12	41.83	11.55	54.94	1.26	4	5.05			1.59
20.00	14.56	41.59	9.33	50.67	0.87	2	1.75			1.07
21.00	10.03	41.36	7.01	46.59	0.50	4	2.01	Simpson		0.69
22.00	6.53	39.36	4.65	42.62	0.31	2	0.63	1/3 rd.		0.41
23.00	3.18	37.10	2.29	38.64	0.15	4	0.59	sum		0.23
24.00	0.00	34.54	0.00	34.54	0.00	1	0.00	11.94	3.98	0.07
				Total Surface Area of AREA 5 (One Side) =					57.25	
				Trapezoidal Strip Area Check -----------------------						57.30

Table 7. Calculation of Wetted Surface Area Five.

Ship Station	Point "A" coord. X	Point "A" coord. Y	Point "B" coord. X	Point "B" coord. Y	Ship Chord |AB|	Simpson Rule Multiplier	Simpson Weight Chord	Simpson sums	Ship Surface Area	Trapezoid Strip Area
(ft.)	(inch)	(inch)	(inch)	(inch)	(ft.)		(ft.)	(ft.)	(ft.^2)	(ft.^2)
57.67	0.00	48.00	0.00	48.00	0.00					
58.00	7.81	47.36	6.83	49.05	0.16	1	0.16		0.03	0.03
59.00	17.65	44.64	13.04	52.62	0.77	4	3.07	Simpson		0.47
60.00	25.95	40.38	16.60	56.58	1.56	2	3.12	1/3 rd.		1.16
61.00	32.90	34.95	18.30	60.24	2.43	4	9.73	sum		2.00
62.00	38.56	28.58	19.19	62.13	3.23	1	3.23	19.31	6.44	2.83
62.65	41.57	24.00	19.50	62.23	3.68				2.24	2.24
62.75	41.57	24.00	21.11	59.44	3.41				0.35	0.35
65.78	41.57	24.00	21.11	59.44	3.41				10.33	10.33
67.00	36.83	30.04	19.50	60.06	2.89	1	2.89		3.84	3.84
68.00	32.84	33.31	19.50	56.40	2.22	4	8.89			2.56
69.00	29.35	35.44	19.50	52.50	1.64	2	3.28			1.93
70.00	27.55	34.38	19.50	48.33	1.34	4	5.37			1.49
71.00	25.47	33.58	19.50	43.86	0.99	2	1.98			1.17
72.00	23.56	32.20	18.81	40.43	0.79	4	3.17			0.89
73.00	21.92	30.11	17.70	37.42	0.70	2	1.41			0.75
74.00	20.02	28.19	16.55	34.21	0.58	4	2.32			0.64
75.00	17.89	36.44	14.77	31.83	0.46	2	0.93			0.52
76.00	15.53	24.80	12.90	29.35	0.44	4	1.75			0.45
77.00	12.98	23.22	10.83	26.94	0.36	2	0.72			0.40
78.00	10.30	21.61	8.60	24.55	0.28	4	1.13	Simpson		0.32
79.00	7.51	19.91	6.24	22.12	0.21	2	0.42	1/3 rd.		0.25
80.00	4.67	18.03	3.88	19.40	0.13	4	0.53	sum		0.17
81.00	1.84	15.86	1.52	16.41	0.05	1	0.05	34.83	11.61	0.09
81.67	0.00	14.20	0.00	14.20	0.00				0.02	0.02
				Total Surface Area of AREA 6 (One Side) =					34.87	
				Trapezoidal Rule Strip Area Check ----------------						34.90

Table 8. Calculation of Wetted Surface Area Six.

Ship Station	Point "A" coord. X	Y	Ship FWD Pod Diameter	Ship FWD Pod Circumf.	Simpson Multiplier	Simpson Weight Chord	Simpson sums	Ship Surface Area	Trapezoid Strip Area
(ft.)	(inch)	(inch)	(ft.)	(ft.)		(ft.)	(ft.)	(ft.^2)	(ft.^2)
0.00	0.00	0.00	0.00	0.00					
0.13	8.76	5.06	1.69	3.53				0.23	0.23
0.25	12.25	7.07	2.36	4.94				0.51	0.51
0.50	16.94	9.78	3.26	6.83	1	6.83		1.47	1.47
1.00	22.50	12.99	4.33	9.07	4	36.28			3.97
1.50	27.36	15.80	5.27	11.03	2	22.06			5.02
2.00	30.23	17.45	5.82	12.18	4	48.73			5.80
2.50	33.09	19.10	6.37	13.34	2	26.67			6.38
3.00	35.08	20.25	6.75	14.14	4	56.55			6.87
3.50	36.75	21.22	7.07	14.81	2	29.63			7.24
4.00	38.35	22.14	7.38	15.46	4	61.83	Simpson		7.57
4.50	39.19	22.63	7.54	15.80	2	31.59	1/3 rd.		7.81
5.00	40.03	23.11	7.70	16.13	4	64.54	sum		7.98
5.50	40.81	23.56	7.85	16.45	1	16.45	401.16	66.86	8.15
6.00	41.14	23.75	7.92	16.58				8.26	8.26
6.65	41.57	24.00	8.00	16.76				10.83	10.83
7.75	41.57	24.00	8.00	16.76				18.43	18.43
8.00	41.57	24.00	8.00	16.76	1	16.76		4.19	4.19
8.50	41.57	24.00	8.00	16.76	4	67.02			8.38
9.00	41.57	24.00	8.00	16.76	2	33.51			8.38
9.50	41.57	24.00	8.00	16.76	4	67.02			8.38
10.00	41.57	24.00	8.00	16.76	2	33.51			8.38
10.50	41.57	24.00	8.00	16.76	4	67.02			8.38
11.00	41.57	24.00	8.00	16.76	2	33.51			8.38
11.50	41.57	24.00	8.00	16.76	4	67.02			8.38
12.00	41.57	24.00	8.00	16.76	2	33.51			8.38
12.50	41.57	24.00	8.00	16.76	4	67.02	Simpson		8.38
13.00	41.57	24.00	8.00	16.76	2	33.51	1/3 rd.		8.38
13.50	41.57	24.00	8.00	16.76	4	67.02	sum		8.38
14.00	38.68	28.43	8.00	17.64	1	17.64	604.08	100.68	8.60
15.00	35.04	32.80	8.00	18.58				18.11	18.11
16.00	32.46	35.36	8.00	19.19				18.89	18.89
16.37	31.19	36.49	8.00	19.48				7.15	7.15
17.00	29.96	36.91	7.92	19.49				12.27	12.27
18.00	25.08	39.50	7.80	20.09	1	20.09		19.79	19.79
19.00	19.12	41.83	7.67	20.80	4	83.18			20.44
20.00	14.56	41.59	7.34	20.60	2	41.20			20.70
21.00	10.03	41.36	7.09	20.60	4	82.38	Simpson		20.60
22.00	6.53	39.36	6.65	19.80	2	39.59	1/3 rd.		20.20
23.00	3.18	37.10	6.21	18.97	4	75.86	sum		19.38
24.00	0.00	34.54	5.76	18.09	1	18.09	360.40	120.13	18.53
33.75	0.00	8.25	1.38	4.32				109.22	109.22
				Total Surface Area of AREA 7 =				517.03	
				Trapezoidal Strip Area Check ------------------					516.75

Table 9. Calculation of Wetted Surface Area Seven.

Ship Station (ft.)	Point "A" coord. X (inch)	Y (inch)	Ship AFT Pod Diameter (ft.)	Ship AFT Pod Circumf. (ft.)	Simpson Multiplier	Simpson Weight Chord (ft.)	Simpson Rule Sums (ft.)	Ship Surface Area (ft.^2)	Trapezoid Strip Area (ft.^2)
51.00	0.00	0.00	0.00	0.00	1	0.00			
52.00	0.00	26.25	4.38	13.74	4	54.98			6.87
53.00	0.00	34.50	5.75	18.06	2	36.13			15.90
54.00	0.00	40.50	6.75	21.21	4	84.82	Simpson		19.63
55.00	0.00	44.25	7.38	23.17	2	46.34	1/3 rd.		22.19
56.00	0.00	46.50	7.75	24.35	4	97.39	sum		23.76
57.00	0.00	47.25	7.88	24.74	1	24.74	344.40	114.80	24.54
57.67	0.00	48.00	8.00	25.13				16.62	16.62
58.00	7.81	47.36	8.00	25.13	1	25.13		8.38	8.38
59.00	17.65	44.64	8.00	22.12	4	88.49	Simpson		23.63
60.00	25.95	40.38	8.00	20.56	2	41.13	1/3 rd.		21.34
61.00	32.90	34.95	8.00	19.09	4	76.36	sum		19.83
62.00	38.56	28.58	8.00	17.67	1	17.67	248.78	82.93	18.38
62.65	41.57	24.00	8.00	16.76				11.19	11.19
62.75	41.57	24.00	8.00	16.76				1.68	1.68
65.78	41.57	24.00	8.00	16.76				50.77	50.77
67.00	36.83	30.04	7.92	17.86	1	17.86		21.12	21.12
68.00	32.84	33.31	7.80	18.42	4	73.70			18.14
69.00	29.35	35.44	7.67	18.79	2	37.58			18.61
70.00	27.55	34.38	7.34	18.11	4	72.43			18.45
71.00	25.47	33.58	7.02	17.51	2	35.02			17.81
72.00	23.56	32.20	6.65	16.69	4	66.76			17.10
73.00	21.92	30.11	6.21	15.59	2	31.19			16.14
74.00	20.02	28.19	5.76	14.55	4	58.18			15.07
75.00	17.89	36.44	6.77	18.17	2	36.34			16.36
76.00	15.53	24.80	4.88	12.59	4	50.37			15.38
77.00	12.98	23.22	4.43	11.67	2	23.34			12.13
78.00	10.30	21.61	3.99	10.76	4	43.04	Simpson		11.21
79.00	7.51	19.91	3.55	9.86	2	19.73	1/3 rd.		10.31
80.00	4.67	18.03	3.10	8.97	4	35.86	sum		9.41
81.00	1.84	15.86	2.66	8.05	1	8.05	609.44	203.15	8.51
81.67	0.00	14.20	2.37	7.44				5.16	5.16
82.00	0.00	13.50	2.25	7.07	1	7.07		2.42	2.42
83.00	0.00	10.50	1.75	5.50	4	21.99	Simpson		6.28
84.00	0.00	8.25	1.38	4.32	2	8.64	1/3 rd.		4.91
85.00	0.00	5.25	0.88	2.75	4	11.00	sum		3.53
86.00	0.00	3.00	0.50	1.57	1	1.57	50.27	16.76	2.16
87.00	0.00	0.00	0.00	0.00				0.79	0.79
				Total Surface Area of AREA 8 =				535.74	
				Trapezoidal Strip Area Check ----------------					535.71

Table 10. Calculation of Wetted Surface Area Eight.

APPENDIX B. RESISTANCE CALCULATIONS

A. ITTC SINGLE LENGTH METHOD

This Table shows the spreadsheet analysis for the ITTC single length method.

Model Velocity (fps)	Model Froude #	Model Total Drag RTm (lbf.)	Model Total CTm	Model Reynolds # L = 11.75'	Model ITTC CFm	Model Friction RFm (lbf.)	Model Residual CRm	Model Residual RRm (lbf.)
2.99	0.15	5	9.91E-03	3251745	3.68E-03	1.86	6.23E-03	3.14
3.27	0.17	5	8.29E-03	3556256	3.62E-03	2.19	4.66E-03	2.81
3.58	0.18	6	8.30E-03	3893393	3.56E-03	2.57	4.74E-03	3.43
3.88	0.20	7	8.24E-03	4219655	3.51E-03	2.98	4.73E-03	4.02
4.17	0.21	15	1.53E-02	4535042	3.46E-03	3.39	1.18E-02	11.61
4.47	0.23	24	2.13E-02	4861304	3.41E-03	3.85	1.79E-02	20.15
4.78	0.25	20	1.55E-02	5198441	3.37E-03	4.35	1.21E-02	15.65
5.08	0.26	25	1.72E-02	5524703	3.33E-03	4.86	1.38E-02	20.14
5.22	0.27	34	2.21E-02	5676959	3.32E-03	5.10	1.88E-02	28.90
5.37	0.28	46	2.83E-02	5840090	3.30E-03	5.37	2.50E-02	40.63
5.52	0.28	60	3.49E-02	6003221	3.28E-03	5.65	3.16E-02	54.35
5.67	0.29	73	4.02E-02	6166352	3.27E-03	5.93	3.70E-02	67.07
5.82	0.30	83	4.34E-02	6329483	3.25E-03	6.22	4.02E-02	76.78
5.97	0.31	90	4.47E-02	6492614	3.24E-03	6.51	4.15E-02	83.49
6.11	0.32	94	4.46E-02	6644870	3.22E-03	6.79	4.14E-02	87.21
6.26	0.32	95	4.30E-02	6808001	3.21E-03	7.10	3.97E-02	87.90
6.57	0.34	91	3.74E-02	7145138	3.18E-03	7.75	3.42E-02	83.25
6.87	0.35	83	3.12E-02	7471400	3.16E-03	8.41	2.80E-02	74.59
7.16	0.37	75	2.59E-02	7786787	3.13E-03	9.07	2.28E-02	65.93
7.46	0.38	67	2.13E-02	8113049	3.11E-03	9.77	1.82E-02	57.23
7.76	0.40	62	1.82E-02	8439311	3.09E-03	10.50	1.52E-02	51.50
8.05	0.42	58	1.59E-02	8754697	3.07E-03	11.23	1.28E-02	46.77
8.35	0.43	56	1.42E-02	9080959	3.05E-03	12.00	1.12E-02	44.00
8.95	0.46	55	1.22E-02	9733483	3.01E-03	13.63	9.15E-03	41.37
9.55	0.49	56	1.09E-02	10386007	2.98E-03	15.34	7.90E-03	40.66
10.14	0.52	58	1.00E-02	11027656	2.95E-03	17.12	7.05E-03	40.88
10.73	0.55	60	9.23E-03	11669305	2.92E-03	18.98	6.31E-03	41.02
11.34	0.58	63	8.68E-03	12332704	2.89E-03	21.00	5.79E-03	42.00
11.93	0.62	67	8.34E-03	12974353	2.87E-03	23.04	5.47E-03	43.96
12.52	0.65	70	7.91E-03	13616001	2.85E-03	25.17	5.07E-03	44.83
13.13	0.68	75	7.71E-03	14279401	2.82E-03	27.46	4.89E-03	47.54
14.33	0.74	84	7.25E-03	15584449	2.78E-03	32.23	4.47E-03	51.77
15.51	0.80	93	6.85E-03	16867746	2.75E-03	37.27	4.11E-03	55.73
16.71	0.86	103	6.54E-03	18172794	2.71E-03	42.73	3.82E-03	60.27
17.91	0.92	113	6.24E-03	19477842	2.68E-03	48.53	3.56E-03	64.47
19.09	0.98	123	5.98E-03	20761139	2.65E-03	54.56	3.33E-03	68.44
20.29	1.05	135	5.81E-03	22066187	2.63E-03	61.02	3.18E-03	73.98
21.49	1.11	147	5.64E-03	23371235	2.60E-03	67.82	3.04E-03	79.18
22.68	1.17	161	5.55E-03	24665408	2.58E-03	74.88	2.97E-03	86.12
23.87	1.23	174	5.41E-03	25959581	2.56E-03	82.27	2.85E-03	91.73

Table 11. ITTC resistance calculations for a single length analysis of the SLICE.

Ship Velocity (fps)	Ship Velocity (kts.)	Ship Froude #	Ship Reynolds # L = 94'	Ship ITTC CFs	Ship Friction RFs (lbf.)	Ship Residual CRs = CRm	Ship Residual RRs (lbf.)	Ship Allowance CA	Ship Allowance RAs (lbf.)
8.46	5.01	0.15	62150743	2.23E-03	593	6.23E-03	1653	0.0005	133
9.25	5.48	0.17	67970880	2.20E-03	700	4.66E-03	1481	0.0005	159
10.13	6.00	0.18	74414602	2.18E-03	828	4.74E-03	1803	0.0005	190
10.97	6.50	0.2	80650463	2.15E-03	961	4.73E-03	2116	0.0005	224
11.79	6.98	0.21	86678461	2.13E-03	1098	1.18E-02	6107	0.0005	258
12.64	7.49	0.23	92914322	2.11E-03	1249	1.79E-02	10603	0.0005	297
13.52	8.01	0.25	99358045	2.09E-03	1415	1.21E-02	8236	0.0005	339
14.37	8.51	0.26	105593905	2.07E-03	1584	1.38E-02	10600	0.0005	383
14.76	8.74	0.27	108503973	2.06E-03	1666	1.88E-02	15206	0.0005	405
15.19	8.99	0.28	111621904	2.05E-03	1756	2.50E-02	21379	0.0005	428
15.61	9.24	0.28	114739834	2.04E-03	1848	3.16E-02	28601	0.0005	452
16.04	9.50	0.29	117857764	2.03E-03	1943	3.70E-02	35293	0.0005	477
16.46	9.75	0.3	120975694	2.03E-03	2039	4.02E-02	40404	0.0005	503
16.89	10.00	0.31	124093625	2.02E-03	2138	4.15E-02	43932	0.0005	529
17.28	10.23	0.32	127003693	2.01E-03	2232	4.14E-02	45890	0.0005	554
17.71	10.48	0.32	130121623	2.01E-03	2335	3.97E-02	46254	0.0005	582
18.58	11.00	0.34	136565346	1.99E-03	2554	3.42E-02	43806	0.0005	641
19.43	11.51	0.35	142801206	1.98E-03	2775	2.80E-02	39250	0.0005	701
20.25	11.99	0.37	148829205	1.97E-03	2997	2.28E-02	34694	0.0005	761
21.10	12.49	0.38	155065065	1.96E-03	3235	1.82E-02	30114	0.0005	826
21.95	13.00	0.4	161300926	1.95E-03	3481	1.52E-02	27099	0.0005	894
22.77	13.48	0.42	167328924	1.94E-03	3727	1.28E-02	24612	0.0005	962
23.62	13.98	0.43	173564785	1.93E-03	3989	1.12E-02	23151	0.0005	1035
25.31	14.99	0.46	186036506	1.91E-03	4539	9.15E-03	21772	0.0005	1189
27.01	15.99	0.49	198508227	1.89E-03	5122	7.90E-03	21396	0.0005	1354
28.68	16.98	0.52	210772086	1.88E-03	5727	7.05E-03	21514	0.0005	1527
30.35	17.97	0.55	223035945	1.86E-03	6363	6.31E-03	21585	0.0005	1710
32.07	18.99	0.58	235715528	1.85E-03	7054	5.79E-03	22101	0.0005	1910
33.74	19.98	0.62	247979387	1.83E-03	7753	5.47E-03	23131	0.0005	2113
35.41	20.97	0.65	260243246	1.82E-03	8483	5.07E-03	23590	0.0005	2328
37.14	21.99	0.68	272922829	1.81E-03	9270	4.89E-03	25015	0.0005	2560
40.53	24.00	0.74	297866272	1.79E-03	10913	4.47E-03	27240	0.0005	3049
43.87	25.98	0.8	322393990	1.77E-03	12649	4.11E-03	29328	0.0005	3572
47.26	27.98	0.86	347337432	1.75E-03	14537	3.82E-03	31717	0.0005	4146
50.66	29.99	0.92	372280874	1.74E-03	16548	3.56E-03	33928	0.0005	4763
53.99	31.97	0.98	396808592	1.72E-03	18642	3.33E-03	36016	0.0005	5411
57.39	33.98	1.05	421752034	1.71E-03	20892	3.18E-03	38928	0.0005	6113
60.78	35.99	1.11	446695476	1.70E-03	23260	3.04E-03	41666	0.0005	6858
64.15	37.98	1.17	471431056	1.68E-03	25726	2.97E-03	45316	0.0005	7638
67.51	39.98	1.23	496166636	1.67E-03	28308	2.85E-03	48271	0.0005	8461

Table 11. ITTC resistance calculations for a single length analysis of the SLICE.

Ship Total CTs	Ship Total Resistance RTs (lbf.)	Ship EHP (hp)	Ship SHP (hp)
8.96E-03	2379	37	50
7.37E-03	2340	39	54
7.41E-03	2821	52	71
7.38E-03	3301	66	90
1.45E-02	7464	160	219
2.05E-02	12149	279	383
1.47E-02	9990	246	336
1.64E-02	12567	328	450
2.14E-02	17277	464	635
2.75E-02	23563	651	891
3.41E-02	30902	877	1202
3.95E-02	37713	1100	1506
4.27E-02	42946	1285	1761
4.40E-02	46599	1431	1960
4.39E-02	48676	1529	2095
4.23E-02	49171	1583	2168
3.67E-02	47001	1588	2175
3.05E-02	42726	1510	2068
2.53E-02	38452	1416	1940
2.07E-02	34175	1311	1796
1.76E-02	31474	1256	1721
1.52E-02	29300	1213	1662
1.36E-02	28176	1210	1657
1.16E-02	27500	1266	1734
1.03E-02	27872	1369	1875
9.42E-03	28768	1500	2055
8.67E-03	29658	1637	2242
8.13E-03	31064	1812	2482
7.81E-03	32998	2024	2773
7.39E-03	34401	2215	3034
7.20E-03	36845	2488	3408
6.76E-03	41202	3036	4159
6.38E-03	45549	3633	4977
6.08E-03	50401	4331	5933
5.80E-03	55238	5088	6969
5.55E-03	60070	5897	8078
5.39E-03	65933	6880	9424
5.23E-03	71784	7933	10867
5.15E-03	78680	9177	12571
5.03E-03	85039	10439	14300

Table 11. ITTC resistance calculations for a single length analysis of the SLICE.

B. ITTC SECTIONALIZED HULL METHOD

This Table shows the spreadsheet analysis for the ITTC sectionalized hull method.

Model Velocity (fps)	Model Froude #	Model Total Drag RTm (lbf.)	Model Total CTm	Reynolds #'s for Model Components Lengths L=3.00' Fwd Strut	L=3.00' Aft Strut	L=4.28175' Fwd Pod	L=4.50' Aft Pod	Model ITTC Coefficients CFm Fwd Strut	Aft Strut	Fwd Pod	Aft Pod
2.99	0.15	5	9.91E-03	830233	830233	1167515	1245349	4.88E-03	4.88E-03	4.53E-03	4.47E-03
3.27	0.17	5	8.29E-03	907980	907980	1276847	1361970	4.79E-03	4.79E-03	4.45E-03	4.39E-03
3.58	0.18	6	8.30E-03	994058	994058	1397894	1491087	4.69E-03	4.69E-03	4.36E-03	4.31E-03
3.88	0.20	7	8.24E-03	1077359	1077359	1515036	1616038	4.61E-03	4.61E-03	4.29E-03	4.23E-03
4.17	0.21	15	1.53E-02	1157883	1157883	1628273	1736825	4.54E-03	4.54E-03	4.23E-03	4.17E-03
4.47	0.23	24	2.13E-02	1241184	1241184	1745415	1861776	4.48E-03	4.48E-03	4.17E-03	4.11E-03
4.78	0.25	20	1.55E-02	1327262	1327262	1866462	1990892	4.41E-03	4.41E-03	4.11E-03	4.06E-03
5.08	0.26	25	1.72E-02	1410563	1410563	1983604	2115844	4.36E-03	4.36E-03	4.06E-03	4.01E-03
5.22	0.27	34	2.21E-02	1449436	1449436	2038270	2174154	4.33E-03	4.33E-03	4.04E-03	3.99E-03
5.37	0.28	46	2.83E-02	1491087	1491087	2096841	2236630	4.31E-03	4.31E-03	4.02E-03	3.96E-03
5.52	0.28	60	3.49E-02	1532737	1532737	2155412	2299106	4.28E-03	4.28E-03	3.99E-03	3.94E-03
5.67	0.29	73	4.02E-02	1574388	1574388	2213983	2361582	4.26E-03	4.26E-03	3.97E-03	3.92E-03
5.82	0.30	83	4.34E-02	1616038	1616038	2272554	2424057	4.23E-03	4.23E-03	3.95E-03	3.90E-03
5.97	0.31	90	4.47E-02	1657689	1657689	2331125	2486533	4.21E-03	4.21E-03	3.93E-03	3.88E-03
6.11	0.32	94	4.46E-02	1696562	1696562	2385791	2544844	4.19E-03	4.19E-03	3.91E-03	3.86E-03
6.26	0.32	95	4.30E-02	1738213	1738213	2444362	2607319	4.17E-03	4.17E-03	3.89E-03	3.85E-03
6.57	0.34	91	3.74E-02	1824291	1824291	2565409	2736436	4.13E-03	4.13E-03	3.86E-03	3.81E-03
6.87	0.35	83	3.12E-02	1907591	1907591	2682551	2861387	4.09E-03	4.09E-03	3.82E-03	3.78E-03
7.16	0.37	75	2.59E-02	1988116	1988116	2795788	2982174	4.06E-03	4.06E-03	3.79E-03	3.75E-03
7.46	0.38	67	2.13E-02	2071417	2071417	2912930	3107125	4.03E-03	4.03E-03	3.76E-03	3.72E-03
7.76	0.40	62	1.82E-02	2154718	2154718	3030072	3232076	3.99E-03	3.99E-03	3.73E-03	3.69E-03
8.05	0.42	58	1.59E-02	2235242	2235242	3143309	3352863	3.96E-03	3.96E-03	3.71E-03	3.66E-03
8.35	0.43	56	1.42E-02	2318543	2318543	3260451	3477814	3.94E-03	3.94E-03	3.68E-03	3.64E-03
8.95	0.46	55	1.22E-02	2485145	2485145	3494735	3727717	3.88E-03	3.88E-03	3.63E-03	3.59E-03
9.55	0.49	56	1.09E-02	2651747	2651747	3729019	3977620	3.83E-03	3.83E-03	3.59E-03	3.55E-03
10.14	0.52	58	1.00E-02	2815572	2815572	3959398	4223358	3.79E-03	3.79E-03	3.55E-03	3.51E-03
10.73	0.55	60	9.23E-03	2979397	2979397	4189777	4469095	3.75E-03	3.75E-03	3.51E-03	3.47E-03
11.34	0.58	63	8.68E-03	3148775	3148775	4427966	4723163	3.71E-03	3.71E-03	3.47E-03	3.43E-03
11.93	0.62	67	8.34E-03	3312601	3312601	4658345	4968901	3.67E-03	3.67E-03	3.44E-03	3.40E-03
12.52	0.65	70	7.91E-03	3476426	3476426	4888724	5214639	3.64E-03	3.64E-03	3.41E-03	3.37E-03
13.13	0.68	75	7.71E-03	3645804	3645804	5126912	5468707	3.60E-03	3.60E-03	3.38E-03	3.34E-03
14.33	0.74	84	7.25E-03	3979008	3979008	5595480	5968512	3.54E-03	3.54E-03	3.33E-03	3.29E-03
15.51	0.80	93	6.85E-03	4306659	4306659	6056239	6459988	3.49E-03	3.49E-03	3.28E-03	3.24E-03
16.71	0.86	103	6.54E-03	4639862	4639862	6524806	6959793	3.44E-03	3.44E-03	3.24E-03	3.20E-03
17.91	0.92	113	6.24E-03	4973066	4973066	6993374	7459599	3.40E-03	3.40E-03	3.20E-03	3.16E-03
19.09	0.98	123	5.98E-03	5300716	5300716	7454132	7951075	3.36E-03	3.36E-03	3.16E-03	3.12E-03
20.29	1.05	135	5.81E-03	5633920	5633920	7922700	8450880	3.32E-03	3.32E-03	3.13E-03	3.09E-03
21.49	1.11	147	5.64E-03	5967124	5967124	8391268	8950686	3.29E-03	3.29E-03	3.09E-03	3.06E-03
22.68	1.17	161	5.55E-03	6297551	6297551	8855931	9446326	3.26E-03	3.26E-03	3.06E-03	3.03E-03
23.87	1.23	174	5.41E-03	6627978	6627978	9320594	9941967	3.23E-03	3.23E-03	3.04E-03	3.00E-03

Table 12. ITTC resistance calculations for a sectionalized hull analysis of the SLICE.

Frictional Resistance of Model Components RFm (lbf.)				Summed Σ RFm (lbf.)	Equivalent Frictional CFm	Model Equivalent Reynolds #	Model Residual CRm	Model Residual RRm (lbf.)	Ship Velocity (fps)	Ship Velocity (kts.)	Ship Froude #
Fwd Strut	Aft Strut	Fwd Pod	Aft Pod								
0.54	0.53	0.63	0.65	2.36	4.67E-03	1019427	5.24E-03	2.64	8.46	5.01	0.15
0.63	0.63	0.74	0.76	2.76	4.58E-03	1114953	3.71E-03	2.24	9.25	5.48	0.17
0.74	0.74	0.88	0.89	3.25	4.49E-03	1220719	3.80E-03	2.75	10.13	6.00	0.18
0.86	0.85	1.01	1.03	3.75	4.42E-03	1323077	3.82E-03	3.25	10.97	6.50	0.20
0.97	0.97	1.15	1.18	4.27	4.35E-03	1422026	1.09E-02	10.73	11.79	6.98	0.21
1.10	1.10	1.30	1.33	4.83	4.29E-03	1524391	1.70E-02	19.17	12.64	7.49	0.23
1.24	1.23	1.47	1.50	5.45	4.23E-03	1630171	1.13E-02	14.55	13.52	8.01	0.25
1.39	1.38	1.64	1.68	6.08	4.17E-03	1732542	1.30E-02	18.92	14.37	8.51	0.26
1.46	1.45	1.72	1.76	6.38	4.15E-03	1780316	1.80E-02	27.62	14.76	8.74	0.27
1.53	1.52	1.81	1.85	6.72	4.13E-03	1831503	2.41E-02	39.28	15.19	8.99	0.28
1.61	1.60	1.90	1.95	7.06	4.10E-03	1882691	3.08E-02	52.94	15.61	9.24	0.28
1.69	1.68	2.00	2.04	7.41	4.08E-03	1933879	3.62E-02	65.59	16.04	9.50	0.29
1.77	1.76	2.09	2.14	7.76	4.06E-03	1985068	3.94E-02	75.24	16.46	9.75	0.30
1.85	1.84	2.19	2.24	8.13	4.04E-03	2036258	4.07E-02	81.87	16.89	10.00	0.31
1.93	1.92	2.29	2.34	8.47	4.02E-03	2084035	4.06E-02	85.53	17.28	10.23	0.32
2.02	2.00	2.39	2.44	8.85	4.00E-03	2135225	3.90E-02	86.15	17.71	10.48	0.32
2.20	2.18	2.61	2.67	9.65	3.96E-03	2241021	3.34E-02	81.35	18.58	11.00	0.34
2.38	2.37	2.82	2.89	10.46	3.93E-03	2343405	2.72E-02	72.54	19.43	11.51	0.35
2.57	2.55	3.04	3.11	11.27	3.90E-03	2442379	2.20E-02	63.73	20.25	11.99	0.37
2.76	2.74	3.28	3.35	12.14	3.86E-03	2544767	1.75E-02	54.86	21.10	12.49	0.38
2.97	2.95	3.52	3.60	13.03	3.83E-03	2647157	1.44E-02	48.97	21.95	13.00	0.40
3.17	3.15	3.76	3.85	13.92	3.81E-03	2746135	1.21E-02	44.08	22.77	13.48	0.42
3.38	3.36	4.02	4.11	14.87	3.78E-03	2848528	1.05E-02	41.13	23.62	13.98	0.43
3.83	3.81	4.55	4.66	16.86	3.73E-03	3053319	8.44E-03	38.14	25.31	14.99	0.46
4.31	4.28	5.12	5.24	18.95	3.68E-03	3258115	7.20E-03	37.05	27.01	15.99	0.49
4.80	4.77	5.71	5.84	21.12	3.64E-03	3459502	6.35E-03	36.88	28.68	16.98	0.52
5.32	5.28	6.32	6.47	23.40	3.60E-03	3660894	5.63E-03	36.60	30.35	17.97	0.55
5.88	5.84	6.99	7.16	25.86	3.56E-03	3869118	5.12E-03	37.14	32.07	18.99	0.58
6.44	6.40	7.66	7.85	28.35	3.53E-03	4070519	4.81E-03	38.65	33.74	19.98	0.62
7.03	6.98	8.36	8.57	30.94	3.50E-03	4271923	4.42E-03	39.06	35.41	20.97	0.65
7.66	7.61	9.12	9.34	33.73	3.47E-03	4480158	4.24E-03	41.27	37.14	21.99	0.68
8.98	8.91	10.69	10.95	39.53	3.41E-03	4889812	3.84E-03	44.47	40.53	24.00	0.74
10.36	10.29	12.34	12.64	45.63	3.36E-03	5292651	3.49E-03	47.37	43.87	25.98	0.80
11.86	11.78	14.13	14.48	52.25	3.32E-03	5702329	3.22E-03	50.75	47.26	27.98	0.86
13.45	13.36	16.04	16.43	59.27	3.27E-03	6112018	2.97E-03	53.73	50.66	29.99	0.92
15.10	15.00	18.01	18.45	66.56	3.24E-03	6514887	2.74E-03	56.44	53.99	31.97	0.98
16.87	16.75	20.13	20.62	74.37	3.20E-03	6924595	2.61E-03	60.63	57.39	33.98	1.05
18.73	18.60	22.35	22.90	82.58	3.17E-03	7334310	2.47E-03	64.42	60.78	35.99	1.11
20.65	20.51	24.66	25.27	91.10	3.14E-03	7740620	2.41E-03	69.90	64.15	37.98	1.17
22.67	22.51	27.07	27.74	100.00	3.11E-03	8146936	2.30E-03	74.00	67.51	39.98	1.23

Table 12. ITTC resistance calculations for a sectionalized hull analysis of the SLICE.

Reynolds #'s for Ship Components Lengths				Ship ITTC Coefficients				Frictional Resistance of Ship Components			
L=24.00'	L=24.00'	L=33.75'	L=36.00'	CFs				RFs (lbf.)			
Fwd Strut	Aft Strut	Fwd Pod	Aft Pod	Fwd Strut	Aft Strut	Fwd Pod	Aft Pod	Fwd Strut	Aft Strut	Fwd Pod	Aft Pod
15868275	15868275	22314762	23802412	2.77E-03	2.77E-03	2.62E-03	2.59E-03	161	160	193	198
17354267	17354267	24404438	26031401	2.73E-03	2.73E-03	2.58E-03	2.56E-03	190	188	227	233
18999473	18999473	26718009	28499209	2.69E-03	2.69E-03	2.55E-03	2.52E-03	224	222	269	276
20591608	20591608	28956948	30887411	2.66E-03	2.66E-03	2.51E-03	2.49E-03	259	258	312	320
22130671	22130671	31121256	33196007	2.63E-03	2.63E-03	2.49E-03	2.46E-03	296	294	356	365
23722806	23722806	33360195	35584208	2.60E-03	2.60E-03	2.46E-03	2.43E-03	337	334	404	415
25368011	25368011	35673766	38052017	2.57E-03	2.57E-03	2.43E-03	2.41E-03	381	378	458	470
26960146	26960146	37912705	40440219	2.54E-03	2.54E-03	2.41E-03	2.39E-03	426	423	512	525
27703142	27703142	38957544	41554713	2.53E-03	2.53E-03	2.40E-03	2.38E-03	448	445	538	552
28499209	28499209	40077013	42748814	2.52E-03	2.52E-03	2.39E-03	2.37E-03	472	468	567	582
29295277	29295277	41196483	43942915	2.51E-03	2.51E-03	2.38E-03	2.36E-03	496	493	597	612
30091344	30091344	42315953	45137016	2.50E-03	2.50E-03	2.37E-03	2.35E-03	521	518	627	643
30887411	30887411	43435422	46331117	2.49E-03	2.49E-03	2.36E-03	2.34E-03	547	543	658	675
31683479	31683479	44554892	47525218	2.48E-03	2.48E-03	2.35E-03	2.33E-03	573	569	690	708
32426475	32426475	45599730	48639712	2.47E-03	2.47E-03	2.34E-03	2.32E-03	598	594	720	739
33222542	33222542	46719200	49833813	2.46E-03	2.46E-03	2.33E-03	2.31E-03	626	621	753	773
34867748	34867748	49032770	52301622	2.44E-03	2.44E-03	2.32E-03	2.29E-03	684	679	823	845
36459882	36459882	51271710	54689824	2.42E-03	2.42E-03	2.30E-03	2.28E-03	743	737	894	917
37998946	37998946	53436018	56998419	2.41E-03	2.41E-03	2.29E-03	2.26E-03	801	796	965	990
39591080	39591080	55674957	59386621	2.39E-03	2.39E-03	2.27E-03	2.25E-03	864	858	1041	1068
41183215	41183215	57913896	61774823	2.38E-03	2.38E-03	2.26E-03	2.24E-03	930	923	1120	1149
42722279	42722279	60078204	64083418	2.37E-03	2.37E-03	2.25E-03	2.22E-03	995	988	1198	1230
44314413	44314413	62317144	66471620	2.35E-03	2.35E-03	2.23E-03	2.21E-03	1064	1057	1282	1316
47498682	47498682	66795022	71248024	2.33E-03	2.33E-03	2.21E-03	2.19E-03	1210	1201	1458	1496
50682952	50682952	71272901	76024427	2.30E-03	2.30E-03	2.19E-03	2.17E-03	1364	1354	1644	1687
53814150	53814150	75676148	80721224	2.28E-03	2.28E-03	2.17E-03	2.15E-03	1524	1513	1837	1886
56945348	56945348	80079395	85418022	2.26E-03	2.26E-03	2.15E-03	2.13E-03	1692	1680	2040	2094
60182688	60182688	84631905	90274032	2.25E-03	2.25E-03	2.13E-03	2.11E-03	1874	1861	2260	2320
63313886	63313886	89035152	94970829	2.23E-03	2.23E-03	2.12E-03	2.10E-03	2058	2044	2483	2549
66445084	66445084	93438400	99667626	2.21E-03	2.21E-03	2.10E-03	2.08E-03	2250	2235	2715	2788
69682425	69682425	97990909	104523637	2.20E-03	2.20E-03	2.09E-03	2.07E-03	2457	2441	2965	3045
76050963	76050963	106946667	114076444	2.17E-03	2.17E-03	2.06E-03	2.04E-03	2889	2870	3488	3582
82313359	82313359	115753161	123470039	2.14E-03	2.14E-03	2.04E-03	2.02E-03	3346	3323	4040	4149
88681897	88681897	124708918	133022846	2.12E-03	2.12E-03	2.02E-03	2.00E-03	3841	3815	4639	4765
95050436	95050436	133664675	142575654	2.10E-03	2.10E-03	2.00E-03	1.98E-03	4368	4338	5277	5420
101312832	101312832	142471170	151969248	2.08E-03	2.08E-03	1.98E-03	1.96E-03	4917	4884	5942	6103
107681370	107681370	151426927	161522056	2.06E-03	2.06E-03	1.96E-03	1.95E-03	5506	5469	6655	6835
114049909	114049909	160382684	171074863	2.04E-03	2.04E-03	1.95E-03	1.93E-03	6126	6084	7405	7606
120365376	120365376	169263810	180548064	2.03E-03	2.03E-03	1.93E-03	1.92E-03	6771	6724	8186	8409
126680843	126680843	178144936	190021265	2.01E-03	2.01E-03	1.92E-03	1.90E-03	7446	7395	9004	9249

Table 12. ITTC resistance calculations for a sectionalized hull analysis of the SLICE.

Summed Σ RFs (lbf.)	Equivalent Frictional CFs	Ship Equivalent Reynolds #	Ship Residual CRs	Ship Residual RRs (lbf.)	Ship Allowance CA	Ship Allowance RAs (lbf.)	Ship Total CTs	Ship Total Resistance RTs (lbf.)	Ship EHP (hp)	Ship SHP (hp)
711	2.68E-03	19511395	5.24E-03	1392	0.0005	133	8.42E-03	2236	34	47
839	2.64E-03	21339224	3.71E-03	1177	0.0005	159	6.85E-03	2175	37	50
990	2.60E-03	23362945	3.80E-03	1448	0.0005	190	6.91E-03	2629	48	66
1148	2.57E-03	25321433	3.82E-03	1710	0.0005	224	6.89E-03	3082	61	84
1311	2.54E-03	27214680	1.09E-02	5648	0.0005	258	1.40E-02	7217	155	212
1490	2.51E-03	29173250	1.70E-02	10086	0.0005	297	2.00E-02	11873	273	374
1686	2.48E-03	31197144	1.13E-02	7656	0.0005	339	1.43E-02	9681	238	326
1886	2.46E-03	33155786	1.30E-02	9956	0.0005	383	1.60E-02	12226	319	438
1983	2.45E-03	34069830	1.80E-02	14532	0.0005	405	2.09E-02	16920	454	622
2089	2.44E-03	35049170	2.41E-02	20672	0.0005	428	2.71E-02	23189	640	877
2198	2.43E-03	36028518	3.08E-02	27859	0.0005	452	3.37E-02	30510	866	1186
2309	2.42E-03	37007873	3.62E-02	34517	0.0005	477	3.91E-02	37304	1088	1490
2423	2.41E-03	37987235	3.94E-02	39592	0.0005	503	4.23E-02	42518	1273	1743
2540	2.40E-03	38966604	4.07E-02	43084	0.0005	529	4.36E-02	46153	1417	1941
2651	2.39E-03	39880688	4.06E-02	45007	0.0005	554	4.35E-02	48212	1515	2075
2772	2.38E-03	40860069	3.90E-02	45335	0.0005	582	4.18E-02	48689	1567	2147
3031	2.36E-03	42884144	3.34E-02	42806	0.0005	641	3.63E-02	46478	1570	2151
3291	2.35E-03	44842950	2.72E-02	38171	0.0005	701	3.01E-02	42163	1490	2041
3552	2.33E-03	46736484	2.20E-02	33536	0.0005	761	2.49E-02	37849	1394	1909
3832	2.32E-03	48695334	1.75E-02	28871	0.0005	826	2.03E-02	33529	1286	1762
4122	2.30E-03	50654204	1.44E-02	25769	0.0005	894	1.72E-02	30785	1229	1683
4411	2.29E-03	52547797	1.21E-02	23195	0.0005	962	1.48E-02	28568	1183	1620
4719	2.28E-03	54506705	1.05E-02	21642	0.0005	1035	1.32E-02	27397	1176	1612
5365	2.26E-03	58424574	8.44E-03	20072	0.0005	1189	1.12E-02	26626	1226	1679
6050	2.23E-03	62342510	7.20E-03	19494	0.0005	1354	9.93E-03	26898	1321	1810
6759	2.21E-03	66195208	6.35E-03	19405	0.0005	1527	9.07E-03	27691	1444	1978
7505	2.19E-03	70047962	5.63E-03	19260	0.0005	1710	8.33E-03	28475	1571	2152
8314	2.18E-03	74031372	5.12E-03	19543	0.0005	1910	7.79E-03	29766	1736	2378
9133	2.16E-03	77884230	4.81E-03	20338	0.0005	2113	7.47E-03	31585	1938	2654
9988	2.15E-03	81737133	4.42E-03	20553	0.0005	2328	7.06E-03	32869	2116	2899
10908	2.13E-03	85720690	4.24E-03	21718	0.0005	2560	6.87E-03	35186	2376	3255
12829	2.10E-03	93557324	3.84E-03	23403	0.0005	3049	6.44E-03	39280	2895	3965
14857	2.08E-03	101263501	3.49E-03	24925	0.0005	3572	6.07E-03	43354	3458	4737
17060	2.06E-03	109100432	3.22E-03	26706	0.0005	4146	5.78E-03	47913	4117	5640
19404	2.04E-03	116937495	2.97E-03	28274	0.0005	4763	5.50E-03	52442	4830	6617
21845	2.02E-03	124644059	2.74E-03	29698	0.0005	5411	5.26E-03	56955	5591	7659
24465	2.00E-03	132481354	2.61E-03	31903	0.0005	6113	5.11E-03	62481	6519	8931
27222	1.98E-03	140318755	2.47E-03	33901	0.0005	6858	4.96E-03	67980	7513	10291
30091	1.97E-03	148090943	2.41E-03	36784	0.0005	7638	4.88E-03	74513	8691	11905
33092	1.96E-03	155863222	2.30E-03	38942	0.0005	8461	4.76E-03	80495	9881	13536

Table 12. ITTC resistance calculations for a sectionalized hull analysis of the SLICE.

C. HUGHES SECTIONALIZED HULL METHOD

This Table shows the spreadsheet analysis for the Hughes sectionalized hull method.

Model	Model	Model	Model	Reynolds #'s for Model Components Lengths				Model Hughes Coefficients			
Velocity	Froude	Total Drag	Total	L=3.00'	L=3.00'	L=4.21875'	L=4.50'	CFOm (no form factor)			
(fps)	#	RTm (lbf.)	CTm	Fwd Strut	Aft Strut	Fwd Pod	Aft Pod	Fwd Strut	Aft Strut	Fwd Pod	Aft Pod
2.99	0.15	5	9.91E-03	830233	830233	1167515	1245349	4.36E-03	4.36E-03	4.05E-03	3.99E-03
3.27	0.17	5	8.29E-03	907980	907980	1276847	1361970	4.28E-03	4.28E-03	3.97E-03	3.92E-03
3.58	0.18	6	8.30E-03	994058	994058	1397894	1491087	4.19E-03	4.19E-03	3.90E-03	3.84E-03
3.88	0.20	7	8.24E-03	1077359	1077359	1515036	1616038	4.12E-03	4.12E-03	3.83E-03	3.78E-03
4.17	0.21	15	1.53E-02	1157883	1157883	1628273	1736825	4.06E-03	4.06E-03	3.77E-03	3.72E-03
4.47	0.23	24	2.13E-02	1241184	1241184	1745415	1861776	4.00E-03	4.00E-03	3.72E-03	3.67E-03
4.78	0.25	20	1.55E-02	1327262	1327262	1866462	1990892	3.94E-03	3.94E-03	3.67E-03	3.62E-03
5.08	0.26	25	1.72E-02	1410563	1410563	1983604	2115844	3.89E-03	3.89E-03	3.62E-03	3.58E-03
5.22	0.27	34	2.21E-02	1449436	1449436	2038270	2174154	3.87E-03	3.87E-03	3.60E-03	3.56E-03
5.37	0.28	46	2.83E-02	1491087	1491087	2096841	2236630	3.84E-03	3.84E-03	3.58E-03	3.54E-03
5.52	0.28	60	3.49E-02	1532737	1532737	2155412	2299106	3.82E-03	3.82E-03	3.56E-03	3.52E-03
5.67	0.29	73	4.02E-02	1574388	1574388	2213983	2361582	3.80E-03	3.80E-03	3.54E-03	3.50E-03
5.82	0.30	83	4.34E-02	1616038	1616038	2272554	2424057	3.78E-03	3.78E-03	3.53E-03	3.48E-03
5.97	0.31	90	4.47E-02	1657689	1657689	2331125	2486533	3.76E-03	3.76E-03	3.51E-03	3.46E-03
6.11	0.32	94	4.46E-02	1696562	1696562	2385791	2544844	3.74E-03	3.74E-03	3.49E-03	3.45E-03
6.26	0.32	95	4.30E-02	1738213	1738213	2444362	2607319	3.72E-03	3.72E-03	3.47E-03	3.43E-03
6.57	0.34	91	3.74E-02	1824291	1824291	2565409	2736436	3.69E-03	3.69E-03	3.44E-03	3.40E-03
6.87	0.35	83	3.12E-02	1907591	1907591	2682551	2861387	3.65E-03	3.65E-03	3.41E-03	3.37E-03
7.16	0.37	75	2.59E-02	1988116	1988116	2795788	2982174	3.62E-03	3.62E-03	3.38E-03	3.34E-03
7.46	0.38	67	2.13E-02	2071417	2071417	2912930	3107125	3.59E-03	3.59E-03	3.36E-03	3.31E-03
7.76	0.40	62	1.82E-02	2154718	2154718	3030072	3232076	3.56E-03	3.56E-03	3.33E-03	3.29E-03
8.05	0.42	58	1.59E-02	2235242	2235242	3143309	3352863	3.54E-03	3.54E-03	3.31E-03	3.27E-03
8.35	0.43	56	1.42E-02	2318543	2318543	3260451	3477814	3.51E-03	3.51E-03	3.28E-03	3.24E-03
8.95	0.46	55	1.22E-02	2485145	2485145	3494735	3727717	3.46E-03	3.46E-03	3.24E-03	3.20E-03
9.55	0.49	56	1.09E-02	2651747	2651747	3729019	3977620	3.42E-03	3.42E-03	3.20E-03	3.16E-03
10.14	0.52	58	1.00E-02	2815572	2815572	3959398	4223358	3.38E-03	3.38E-03	3.16E-03	3.12E-03
10.73	0.55	60	9.23E-03	2979397	2979397	4189777	4469095	3.34E-03	3.34E-03	3.13E-03	3.09E-03
11.34	0.58	63	8.68E-03	3148775	3148775	4427966	4723163	3.31E-03	3.31E-03	3.10E-03	3.06E-03
11.93	0.62	67	8.34E-03	3312601	3312601	4658345	4968901	3.27E-03	3.27E-03	3.07E-03	3.03E-03
12.52	0.65	70	7.91E-03	3476426	3476426	4888724	5214639	3.24E-03	3.24E-03	3.04E-03	3.00E-03
13.13	0.68	75	7.71E-03	3645804	3645804	5126912	5468707	3.21E-03	3.21E-03	3.01E-03	2.98E-03
14.33	0.74	84	7.25E-03	3979008	3979008	5595480	5968512	3.16E-03	3.16E-03	2.97E-03	2.93E-03
15.51	0.80	93	6.85E-03	4306659	4306659	6056239	6459988	3.11E-03	3.11E-03	2.92E-03	2.89E-03
16.71	0.86	103	6.54E-03	4639862	4639862	6524806	6959793	3.07E-03	3.07E-03	2.88E-03	2.85E-03
17.91	0.92	113	6.24E-03	4973066	4973066	6993374	7459599	3.03E-03	3.03E-03	2.85E-03	2.81E-03
19.09	0.98	123	5.98E-03	5300716	5300716	7454132	7951075	2.99E-03	2.99E-03	2.81E-03	2.78E-03
20.29	1.05	135	5.81E-03	5633920	5633920	7922700	8450880	2.96E-03	2.96E-03	2.78E-03	2.75E-03
21.49	1.11	147	5.64E-03	5967124	5967124	8391268	8950686	2.93E-03	2.93E-03	2.76E-03	2.72E-03
22.68	1.17	161	5.55E-03	6297551	6297551	8855931	9446326	2.90E-03	2.90E-03	2.73E-03	2.70E-03
23.87	1.23	174	5.41E-03	6627978	6627978	9320594	9941967	2.87E-03	2.87E-03	2.71E-03	2.67E-03

Table 13. Hughes resistance calculations for a sectionalized hull analysis of the SLICE.

Frictional Resistance of Model Components				Summed	Equivalent	Model	Reynolds Scaled Resistance		Model	Model
RFOm (lbf.)				Σ RFOm	Frictional	Equivalent	(Frictional + Form)		Form	Form Drag
Fwd Strut	Aft Strut	Fwd Pod	Aft Pod	(lbf.)	CFOm	Reynolds #	(r * CFOm)	R(Rn)m (lbf.)	Cform.m	(lbf.)
0.48	0.48	0.57	0.58	2.10	4.17E-03	1019383	8.13E-03	4.10E+00	3.96E-03	2.00
0.56	0.56	0.66	0.68	2.47	4.09E-03	1114906	7.97E-03	4.81E+00	3.89E-03	2.34
0.66	0.66	0.78	0.80	2.90	4.01E-03	1220668	7.82E-03	5.66E+00	3.81E-03	2.76
0.76	0.76	0.90	0.92	3.35	3.94E-03	1323023	7.69E-03	6.53E+00	3.75E-03	3.18
0.87	0.86	1.03	1.05	3.81	3.88E-03	1421969	7.57E-03	7.43E+00	3.69E-03	3.62
0.98	0.98	1.16	1.19	4.31	3.83E-03	1524331	7.46E-03	8.41E+00	3.64E-03	4.10
1.11	1.10	1.31	1.34	4.87	3.77E-03	1630107	7.36E-03	9.49E+00	3.58E-03	4.62
1.24	1.23	1.46	1.50	5.43	3.73E-03	1732475	7.27E-03	1.06E+01	3.54E-03	5.16
1.30	1.29	1.54	1.57	5.70	3.71E-03	1780248	7.23E-03	1.11E+01	3.52E-03	5.41
1.37	1.36	1.62	1.65	6.00	3.68E-03	1831433	7.18E-03	1.17E+01	3.50E-03	5.70
1.44	1.43	1.70	1.74	6.30	3.66E-03	1882619	7.14E-03	1.23E+01	3.48E-03	5.98
1.51	1.50	1.78	1.82	6.61	3.64E-03	1933806	7.10E-03	1.29E+01	3.46E-03	6.28
1.58	1.57	1.87	1.91	6.93	3.62E-03	1984994	7.07E-03	1.35E+01	3.44E-03	6.58
1.65	1.64	1.96	2.00	7.25	3.60E-03	2036181	7.03E-03	1.41E+01	3.42E-03	6.89
1.72	1.71	2.04	2.09	7.56	3.59E-03	2083957	7.00E-03	1.47E+01	3.41E-03	7.18
1.80	1.79	2.13	2.18	7.90	3.57E-03	2135146	6.96E-03	1.54E+01	3.39E-03	7.50
1.96	1.95	2.32	2.38	8.61	3.54E-03	2240939	6.89E-03	1.68E+01	3.36E-03	8.18
2.13	2.11	2.52	2.58	9.33	3.50E-03	2343320	6.83E-03	1.82E+01	3.33E-03	8.87
2.29	2.27	2.71	2.78	10.06	3.48E-03	2442291	6.78E-03	1.96E+01	3.30E-03	9.55
2.47	2.45	2.92	2.99	10.83	3.45E-03	2544676	6.72E-03	2.11E+01	3.27E-03	10.29
2.65	2.63	3.14	3.21	11.62	3.42E-03	2647063	6.67E-03	2.27E+01	3.25E-03	11.04
2.83	2.81	3.35	3.43	12.42	3.40E-03	2746039	6.62E-03	2.42E+01	3.23E-03	11.80
3.02	3.00	3.58	3.67	13.27	3.37E-03	2848429	6.57E-03	2.59E+01	3.20E-03	12.60
3.42	3.40	4.06	4.16	15.03	3.33E-03	3053214	6.49E-03	2.93E+01	3.16E-03	14.28
3.85	3.82	4.57	4.67	16.90	3.28E-03	3258004	6.40E-03	3.30E+01	3.12E-03	16.06
4.28	4.25	5.09	5.21	18.84	3.25E-03	3459386	6.33E-03	3.67E+01	3.08E-03	17.90
4.74	4.71	5.64	5.77	20.87	3.21E-03	3660773	6.26E-03	4.07E+01	3.05E-03	19.82
5.24	5.21	6.23	6.38	23.06	3.18E-03	3868991	6.20E-03	4.50E+01	3.02E-03	21.91
5.75	5.71	6.83	6.99	25.28	3.15E-03	4070386	6.14E-03	4.93E+01	2.99E-03	24.01
6.27	6.23	7.46	7.64	27.59	3.12E-03	4271785	6.08E-03	5.38E+01	2.96E-03	26.21
6.83	6.79	8.13	8.32	30.07	3.09E-03	4480015	6.03E-03	5.86E+01	2.94E-03	28.56
8.00	7.95	9.53	9.76	35.23	3.04E-03	4889658	5.93E-03	6.87E+01	2.89E-03	33.47
9.24	9.17	11.00	11.27	40.67	3.00E-03	5292487	5.84E-03	7.93E+01	2.85E-03	38.64
10.57	10.50	12.59	12.90	46.57	2.95E-03	5702154	5.76E-03	9.08E+01	2.81E-03	44.24
11.99	11.91	14.29	14.64	52.82	2.92E-03	6111833	5.69E-03	1.03E+02	2.77E-03	50.18
13.46	13.37	16.05	16.44	59.31	2.88E-03	6514693	5.62E-03	1.16E+02	2.74E-03	56.35
15.03	14.93	17.93	18.37	66.27	2.85E-03	6924390	5.56E-03	1.29E+02	2.71E-03	62.96
16.69	16.57	19.91	20.40	73.57	2.82E-03	7334096	5.50E-03	1.43E+02	2.68E-03	69.89
18.41	18.28	21.97	22.51	81.16	2.80E-03	7740395	5.45E-03	1.58E+02	2.66E-03	77.10
20.20	20.06	24.11	24.71	89.08	2.77E-03	8146702	5.40E-03	1.74E+02	2.63E-03	84.63

Table 13. Hughes resistance calculations for a sectionalized hull analysis of the SLICE.

Model	Model	Model	Model	Ship	Ship	Ship	Reynolds # 's for Ship Components Lengths			
Wave Making	Wave Making	Residual	Residual	Velocity	Velocity	Froude	L=24.00'	L=24.00'	L=33.75'	L=36.00'
CWMm	RWMm (lbf.)	CRm	RRm (lbf.)	(fps)	(kts.)	#	Fwd Strut	Aft Strut	Fwd Pod	Aft Pod
1.78E-03	0.90	5.74E-03	2.90	8.46	5.01	0.15	15868275	15868275	22314762	23802412
3.11E-04	0.19	4.20E-03	2.53	9.25	5.48	0.17	17354267	17354267	24404438	26031401
4.74E-04	0.34	4.28E-03	3.10	10.13	6.00	0.18	18999473	18999473	26718009	28499209
5.51E-04	0.47	4.30E-03	3.65	10.97	6.50	0.20	20591608	20591608	28956948	30887411
7.71E-03	7.57	1.14E-02	11.19	11.79	6.98	0.21	22130671	22130671	31121256	33196007
1.38E-02	15.59	1.75E-02	19.69	12.64	7.49	0.23	23722806	23722806	33360195	35584208
8.15E-03	10.51	1.17E-02	15.13	13.52	8.01	0.25	25368011	25368011	35673766	38052017
9.90E-03	14.42	1.34E-02	19.57	14.37	8.51	0.26	26960146	26960146	37912705	40440219
1.49E-02	22.89	1.84E-02	28.30	14.76	8.74	0.27	27703142	27703142	38957544	41554713
2.11E-02	34.31	2.46E-02	40.00	15.19	8.99	0.28	28499209	28499209	40077013	42748814
2.77E-02	47.72	3.12E-02	53.70	15.61	9.24	0.28	29295277	29295277	41196483	43942915
3.31E-02	60.11	3.66E-02	66.39	16.04	9.50	0.29	30091344	30091344	42315953	45137016
3.64E-02	69.49	3.98E-02	76.07	16.46	9.75	0.30	30887411	30887411	43435422	46331117
3.77E-02	75.86	4.11E-02	82.75	16.89	10.00	0.31	31683479	31683479	44554892	47525218
3.76E-02	79.26	4.10E-02	86.44	17.28	10.23	0.32	32426475	32426475	45599730	48639712
3.60E-02	79.60	3.94E-02	87.10	17.71	10.48	0.32	33222542	33222542	46719200	49833813
3.05E-02	74.20	3.38E-02	82.39	18.58	11.00	0.34	34867748	34867748	49032770	52301622
2.43E-02	64.80	2.77E-02	73.67	19.43	11.51	0.35	36459882	36459882	51271710	54689824
1.91E-02	55.39	2.24E-02	64.94	20.25	11.99	0.37	37998946	37998946	53436018	56998419
1.46E-02	45.89	1.79E-02	56.17	21.10	12.49	0.38	39591080	39591080	55674957	59386621
1.16E-02	39.33	1.48E-02	50.38	21.95	13.00	0.40	41183215	41183215	57913896	61774823
9.24E-03	33.78	1.25E-02	45.58	22.77	13.48	0.42	42722279	42722279	60078204	64083418
7.66E-03	30.13	1.09E-02	42.73	23.62	13.98	0.43	44314413	44314413	62317144	66471620
5.68E-03	25.68	8.84E-03	39.97	25.31	14.99	0.46	47498682	47498682	66795022	71248024
4.48E-03	23.04	7.60E-03	39.10	27.01	15.99	0.49	50682952	50682952	71272901	76024427
3.67E-03	21.27	6.75E-03	39.16	28.68	16.98	0.52	53814150	53814150	75676148	80721224
2.97E-03	19.31	6.02E-03	39.13	30.35	17.97	0.55	56945348	56945348	80079395	85418022
2.48E-03	18.03	5.50E-03	39.94	32.07	18.99	0.58	60182688	60182688	84631905	90274032
2.20E-03	17.71	5.19E-03	41.72	33.74	19.98	0.62	63313886	63313886	89035152	94970829
1.83E-03	16.21	4.79E-03	42.41	35.41	20.97	0.65	66445084	66445084	93438400	99667626
1.68E-03	16.37	4.62E-03	44.93	37.14	21.99	0.68	69682425	69682425	97990909	104523637
1.32E-03	15.29	4.21E-03	48.77	40.53	24.00	0.74	76050963	76050963	106946667	114076444
1.01E-03	13.69	3.85E-03	52.33	43.87	25.98	0.80	82313359	82313359	115753161	123470039
7.74E-04	12.20	3.58E-03	56.43	47.26	27.98	0.86	88681897	88681897	124708918	133022846
5.53E-04	10.01	3.32E-03	60.18	50.66	29.99	0.92	95050436	95050436	133664675	142575654
3.57E-04	7.34	3.10E-03	63.69	53.99	31.97	0.98	101312832	101312832	142471170	151969248
2.49E-04	5.78	2.96E-03	68.73	57.39	33.98	1.05	107681370	107681370	151426927	161522056
1.36E-04	3.53	2.82E-03	73.43	60.78	35.99	1.11	114049909	114049909	160382684	171074863
9.44E-05	2.74	2.75E-03	79.84	64.15	37.98	1.17	120365376	120365376	169263810	180548064
8.98E-06	0.29	2.64E-03	84.92	67.51	39.98	1.23	126680843	126680843	178144936	190021265

Table 13. Hughes resistance calculations for a sectionalized hull analysis of the SLICE.

Ship Hughes Coefficients				Frictional Resistance of Ship Components				Summed	Equivalent	Ship
CFOs (no form factor)				RFOs (lbf.)				Σ RFOs	Frictional	Equivalent
Fwd Strut	Aft Strut	Fwd Pod	Aft Pod	Fwd Strut	Aft Strut	Fwd Pod	Aft Pod	(lbf.)	CFOs	Reynolds #
2.47E-03	2.47E-03	2.33E-03	2.31E-03	143	142	172	176	633	2.39E-03	19510913
2.43E-03	2.43E-03	2.30E-03	2.28E-03	169	168	202	208	746	2.35E-03	21338704
2.40E-03	2.40E-03	2.27E-03	2.24E-03	199	198	239	245	881	2.32E-03	23362384
2.36E-03	2.36E-03	2.24E-03	2.21E-03	231	229	277	284	1022	2.29E-03	25320833
2.34E-03	2.34E-03	2.21E-03	2.19E-03	264	262	317	325	1167	2.26E-03	27214042
2.31E-03	2.31E-03	2.19E-03	2.17E-03	300	297	360	369	1326	2.23E-03	29172574
2.29E-03	2.29E-03	2.16E-03	2.14E-03	339	336	407	418	1500	2.21E-03	31196429
2.26E-03	2.26E-03	2.14E-03	2.12E-03	379	376	455	467	1678	2.19E-03	33155034
2.25E-03	2.25E-03	2.13E-03	2.11E-03	398	396	479	491	1764	2.18E-03	34069060
2.24E-03	2.24E-03	2.13E-03	2.10E-03	420	417	504	518	1859	2.17E-03	35048382
2.23E-03	2.23E-03	2.12E-03	2.09E-03	441	438	531	545	1955	2.16E-03	36027711
2.22E-03	2.22E-03	2.11E-03	2.09E-03	464	461	558	572	2054	2.15E-03	37007048
2.21E-03	2.21E-03	2.10E-03	2.08E-03	487	483	585	601	2156	2.14E-03	37986392
2.21E-03	2.21E-03	2.09E-03	2.07E-03	510	506	613	629	2259	2.13E-03	38965742
2.20E-03	2.20E-03	2.08E-03	2.06E-03	532	529	640	657	2358	2.13E-03	39879809
2.19E-03	2.19E-03	2.08E-03	2.05E-03	557	553	669	687	2466	2.12E-03	40859172
2.17E-03	2.17E-03	2.06E-03	2.04E-03	608	604	732	751	2696	2.10E-03	42883210
2.16E-03	2.16E-03	2.05E-03	2.03E-03	661	656	795	816	2927	2.09E-03	44841980
2.14E-03	2.14E-03	2.03E-03	2.01E-03	713	708	858	881	3159	2.08E-03	46735479
2.13E-03	2.13E-03	2.02E-03	2.00E-03	769	764	926	950	3408	2.06E-03	48694293
2.12E-03	2.12E-03	2.01E-03	1.99E-03	827	821	996	1022	3665	2.05E-03	50653128
2.10E-03	2.10E-03	2.00E-03	1.98E-03	885	879	1065	1094	3922	2.04E-03	52546687
2.09E-03	2.09E-03	1.99E-03	1.97E-03	947	940	1140	1170	4197	2.03E-03	54505560
2.07E-03	2.07E-03	1.97E-03	1.95E-03	1076	1069	1296	1330	4771	2.01E-03	58423360
2.05E-03	2.05E-03	1.95E-03	1.93E-03	1213	1205	1461	1500	5379	1.99E-03	62341227
2.03E-03	2.03E-03	1.93E-03	1.91E-03	1355	1346	1633	1676	6010	1.97E-03	66193858
2.01E-03	2.01E-03	1.91E-03	1.90E-03	1504	1494	1813	1862	6673	1.95E-03	70046545
2.00E-03	2.00E-03	1.90E-03	1.88E-03	1666	1655	2009	2062	7392	1.94E-03	74029887
1.98E-03	1.98E-03	1.88E-03	1.87E-03	1830	1817	2207	2266	8120	1.92E-03	77882679
1.97E-03	1.97E-03	1.87E-03	1.85E-03	2001	1987	2413	2478	8879	1.91E-03	81735518
1.95E-03	1.95E-03	1.86E-03	1.84E-03	2185	2170	2636	2706	9697	1.89E-03	85719008
1.93E-03	1.93E-03	1.83E-03	1.82E-03	2569	2551	3100	3183	11403	1.87E-03	93555512
1.91E-03	1.91E-03	1.81E-03	1.80E-03	2974	2954	3590	3687	13206	1.85E-03	101261561
1.88E-03	1.88E-03	1.79E-03	1.78E-03	3415	3391	4123	4234	15163	1.83E-03	109098365
1.87E-03	1.87E-03	1.78E-03	1.76E-03	3883	3856	4690	4816	17246	1.81E-03	116935301
1.85E-03	1.85E-03	1.76E-03	1.74E-03	4371	4341	5280	5423	19415	1.79E-03	124641742
1.83E-03	1.83E-03	1.74E-03	1.73E-03	4894	4861	5914	6074	21742	1.78E-03	132478913
1.82E-03	1.82E-03	1.73E-03	1.72E-03	5445	5407	6580	6759	24191	1.76E-03	140316191
1.80E-03	1.80E-03	1.72E-03	1.70E-03	6018	5976	7274	7471	26739	1.75E-03	148088257
1.79E-03	1.79E-03	1.71E-03	1.69E-03	6617	6572	8000	8217	29406	1.74E-03	155860415

Table 13. Hughes resistance calculations for a sectionalized hull analysis of the SLICE.

Reynolds Scaled Resistance		Ship	Ship	Ship	Ship	Ship	Ship	Ship	Ship
(Frictional + Form)		Form	From Drag	Wave Making	Wave Making	Residual	Residual	Allowance	Allowance
(r*CFOs)	R(Rn)s (lbf.)	Cform.s	(lbf.)	CWMs	RWMs (lbf.)	CRs	RRs (lbf.)	CA	RAs (lbf.)
4.65E-03	1235	2.27E-03	602	1.78E-03	472	4.04E-03	1074	0.0005	133
4.58E-03	1455	2.23E-03	709	3.11E-04	99	2.54E-03	808	0.0005	159
4.52E-03	1719	2.20E-03	837	4.74E-04	181	2.67E-03	1018	0.0005	190
4.46E-03	1993	2.17E-03	971	5.51E-04	246	2.72E-03	1217	0.0005	224
4.41E-03	2275	2.15E-03	1108	7.71E-03	3983	9.86E-03	5092	0.0005	258
4.36E-03	2585	2.12E-03	1260	1.38E-02	8202	1.59E-02	9461	0.0005	297
4.31E-03	2925	2.10E-03	1425	8.15E-03	5532	1.03E-02	6957	0.0005	339
4.27E-03	3272	2.08E-03	1594	9.90E-03	7587	1.20E-02	9181	0.0005	383
4.25E-03	3440	2.07E-03	1676	1.49E-02	12045	1.70E-02	13721	0.0005	405
4.23E-03	3624	2.06E-03	1766	2.11E-02	18054	2.31E-02	19820	0.0005	428
4.21E-03	3813	2.05E-03	1858	2.77E-02	25110	2.98E-02	26967	0.0005	452
4.20E-03	4006	2.04E-03	1952	3.31E-02	31632	3.52E-02	33584	0.0005	477
4.18E-03	4204	2.04E-03	2048	3.64E-02	36568	3.84E-02	38616	0.0005	503
4.16E-03	4406	2.03E-03	2146	3.77E-02	39919	3.97E-02	42066	0.0005	529
4.15E-03	4598	2.02E-03	2240	3.76E-02	41708	3.96E-02	43948	0.0005	554
4.13E-03	4808	2.01E-03	2342	3.60E-02	41888	3.80E-02	44231	0.0005	582
4.10E-03	5257	2.00E-03	2561	3.05E-02	39048	3.25E-02	41609	0.0005	641
4.07E-03	5708	1.98E-03	2781	2.43E-02	34099	2.63E-02	36879	0.0005	701
4.05E-03	6161	1.97E-03	3001	1.91E-02	29149	2.11E-02	32150	0.0005	761
4.02E-03	6646	1.96E-03	3238	1.46E-02	24147	1.66E-02	27385	0.0005	826
4.00E-03	7148	1.95E-03	3482	1.16E-02	20698	1.35E-02	24180	0.0005	894
3.97E-03	7649	1.94E-03	3726	9.24E-03	17778	1.12E-02	21504	0.0005	962
3.95E-03	8184	1.93E-03	3987	7.66E-03	15856	9.58E-03	19843	0.0005	1035
3.91E-03	9303	1.91E-03	4532	5.68E-03	13514	7.59E-03	18047	0.0005	1189
3.87E-03	10489	1.89E-03	5110	4.48E-03	12123	6.36E-03	17233	0.0005	1354
3.84E-03	11719	1.87E-03	5709	3.67E-03	11191	5.53E-03	16901	0.0005	1527
3.81E-03	13012	1.85E-03	6339	2.97E-03	10163	4.83E-03	16502	0.0005	1710
3.77E-03	14414	1.84E-03	7022	2.48E-03	9490	4.32E-03	16512	0.0005	1910
3.75E-03	15834	1.82E-03	7714	2.20E-03	9320	4.03E-03	17033	0.0005	2113
3.72E-03	17314	1.81E-03	8435	1.83E-03	8529	3.64E-03	16964	0.0005	2328
3.69E-03	18909	1.80E-03	9212	1.68E-03	8613	3.48E-03	17825	0.0005	2560
3.65E-03	22237	1.78E-03	10833	1.32E-03	8048	3.10E-03	18882	0.0005	3049
3.60E-03	25751	1.76E-03	12545	1.01E-03	7203	2.76E-03	19748	0.0005	3572
3.57E-03	29568	1.74E-03	14405	7.74E-04	6419	2.51E-03	20824	0.0005	4146
3.53E-03	33629	1.72E-03	16384	5.53E-04	5265	2.27E-03	21649	0.0005	4763
3.50E-03	37858	1.70E-03	18444	3.57E-04	3862	2.06E-03	22306	0.0005	5411
3.47E-03	42397	1.69E-03	20655	2.49E-04	3040	1.94E-03	23694	0.0005	6113
3.44E-03	47172	1.68E-03	22981	1.36E-04	1859	1.81E-03	24840	0.0005	6858
3.41E-03	52141	1.66E-03	25402	9.44E-05	1442	1.76E-03	26844	0.0005	7638
3.39E-03	57341	1.65E-03	27935	8.98E-06	152	1.66E-03	28087	0.0005	8461

Table 13. Hughes resistance calculations for a sectionalized hull analysis of the SLICE.

Ship Total CTs	Ship Total Resistance RTs (lbf.)	Ship EHP (hp)	Ship SHP (hp)	Model Reynolds Scaled C	Model Reynolds Scaled (lbf.)	Model Froude Scaled C	Model Froude Scaled (lbf.)	Ship Reynolds Scaled C	Ship Reynolds Scaled (lbf.)	Ship Froude Scaled C	Ship Froude Scaled (lbf.)
6.93E-03	1840	28	39	8.13E-03	4	1.78E-03	0.90	4.65E-03	1235	1.78E-03	472
5.39E-03	1713	29	39	7.97E-03	5	3.11E-04	0.19	4.58E-03	1455	3.11E-04	99
5.49E-03	2090	38	53	7.82E-03	6	4.74E-04	0.34	4.52E-03	1719	4.74E-04	181
5.51E-03	2463	49	67	7.69E-03	7	5.51E-04	0.47	4.46E-03	1993	5.51E-04	246
1.26E-02	6517	140	191	7.57E-03	7	7.71E-03	7.57	4.41E-03	2275	7.71E-03	3983
1.87E-02	11084	255	349	7.46E-03	8	1.38E-02	15.59	4.36E-03	2585	1.38E-02	8202
1.30E-02	8796	216	296	7.36E-03	9	8.15E-03	10.51	4.31E-03	2925	8.15E-03	5532
1.47E-02	11242	294	402	7.27E-03	11	9.90E-03	14.42	4.27E-03	3272	9.90E-03	7587
1.96E-02	15889	427	584	7.23E-03	11	1.49E-02	22.89	4.25E-03	3440	1.49E-02	12045
2.58E-02	22107	610	836	7.18E-03	12	2.11E-02	34.31	4.23E-03	3624	2.11E-02	18054
3.25E-02	29375	834	1142	7.14E-03	12	2.77E-02	47.72	4.21E-03	3813	2.77E-02	25110
3.78E-02	36115	1053	1443	7.10E-03	13	3.31E-02	60.11	4.20E-03	4006	3.31E-02	31632
4.10E-02	41275	1235	1692	7.07E-03	14	3.64E-02	69.49	4.18E-03	4204	3.64E-02	36568
4.24E-02	44854	1377	1886	7.03E-03	14	3.77E-02	75.86	4.16E-03	4406	3.77E-02	39919
4.23E-02	46860	1472	2017	7.00E-03	15	3.76E-02	79.26	4.15E-03	4598	3.76E-02	41708
4.06E-02	47279	1522	2085	6.96E-03	15	3.60E-02	79.60	4.13E-03	4808	3.60E-02	41888
3.51E-02	44945	1519	2080	6.89E-03	17	3.05E-02	74.20	4.10E-03	5257	3.05E-02	39048
2.89E-02	40507	1431	1960	6.83E-03	18	2.43E-02	64.80	4.07E-03	5708	2.43E-02	34099
2.37E-02	36071	1328	1819	6.78E-03	20	1.91E-02	55.39	4.05E-03	6161	1.91E-02	29149
1.91E-02	31619	1213	1662	6.72E-03	21	1.46E-02	45.89	4.02E-03	6646	1.46E-02	24147
1.61E-02	28740	1147	1571	6.67E-03	23	1.16E-02	39.33	4.00E-03	7148	1.16E-02	20698
1.37E-02	26389	1092	1496	6.62E-03	24	9.24E-03	33.78	3.97E-03	7649	9.24E-03	17778
1.21E-02	25075	1077	1475	6.57E-03	26	7.66E-03	30.13	3.95E-03	8184	7.66E-03	15856
1.01E-02	24007	1105	1514	6.49E-03	29	5.68E-03	25.68	3.91E-03	9303	5.68E-03	13514
8.85E-03	23967	1177	1612	6.40E-03	33	4.48E-03	23.04	3.87E-03	10489	4.48E-03	12123
8.00E-03	24437	1274	1746	6.33E-03	37	3.67E-03	21.27	3.84E-03	11719	3.67E-03	11191
7.28E-03	24885	1373	1881	6.26E-03	41	2.97E-03	19.31	3.81E-03	13012	2.97E-03	10163
6.76E-03	25813	1505	2062	6.20E-03	45	2.48E-03	18.03	3.77E-03	14414	2.48E-03	9490
6.45E-03	27267	1673	2292	6.14E-03	49	2.20E-03	17.71	3.75E-03	15834	2.20E-03	9320
6.05E-03	28171	1814	2485	6.08E-03	54	1.83E-03	16.21	3.72E-03	17314	1.83E-03	8529
5.88E-03	30082	2031	2782	6.03E-03	59	1.68E-03	16.37	3.69E-03	18909	1.68E-03	8613
5.47E-03	33334	2457	3365	5.93E-03	69	1.32E-03	15.29	3.65E-03	22237	1.32E-03	8048
5.11E-03	36526	2913	3991	5.84E-03	79	1.01E-03	13.69	3.60E-03	25751	1.01E-03	7203
4.84E-03	40133	3449	4724	5.76E-03	91	7.74E-04	12.20	3.57E-03	29568	7.74E-04	6419
4.58E-03	43658	4021	5508	5.69E-03	103	5.53E-04	10.01	3.53E-03	33629	5.53E-04	5265
4.35E-03	47132	4627	6338	5.62E-03	116	3.57E-04	7.34	3.50E-03	37858	3.57E-04	3862
4.22E-03	51549	5379	7368	5.56E-03	129	2.49E-04	5.78	3.47E-03	42397	2.49E-04	3040
4.07E-03	55889	6176	8461	5.50E-03	143	1.36E-04	3.53	3.44E-03	47172	1.36E-04	1859
4.01E-03	61221	7140	9781	5.45E-03	158	9.44E-05	2.74	3.41E-03	52141	9.44E-05	1442
3.90E-03	65954	8096	11090	5.40E-03	174	8.98E-06	0.29	3.39E-03	57341	8.98E-06	152

Table 13. Hughes resistance calculations for a sectionalized hull analysis of the SLICE.

D. MODIFIED HUGHES METHOD

This Table shows the spreadsheet analysis for the modified Hughes method.

Model	Model	Model	Model	Reynolds #'s for Model Components Lengths				Model Hughes Coefficients			
Velocity	Froude	Total Drag	Total	L=3.00'	L=3.00'	L=4.21875'	L=4.50'	CFOm (no form factor)			
(fps)	#	RTm (lbf.)	CTm	Fwd Strut	Aft Strut	Fwd Pod	Aft Pod	Fwd Strut	Aft Strut	Fwd Pod	Aft Pod
2.99	0.15	5	9.91E-03	830233	830233	1167515	1245349	4.36E-03	4.36E-03	4.05E-03	3.99E-03
3.27	0.17	5	8.29E-03	907980	907980	1276847	1361970	4.28E-03	4.28E-03	3.97E-03	3.92E-03
3.58	0.18	6	8.30E-03	994058	994058	1397894	1491087	4.19E-03	4.19E-03	3.90E-03	3.84E-03
3.88	0.20	7	8.24E-03	1077359	1077359	1515036	1616038	4.12E-03	4.12E-03	3.83E-03	3.78E-03
4.17	0.21	15	1.53E-02	1157883	1157883	1628273	1736825	4.06E-03	4.06E-03	3.77E-03	3.72E-03
4.47	0.23	24	2.13E-02	1241184	1241184	1745415	1861776	4.00E-03	4.00E-03	3.72E-03	3.67E-03
4.78	0.25	20	1.55E-02	1327262	1327262	1866462	1990892	3.94E-03	3.94E-03	3.67E-03	3.62E-03
5.08	0.26	25	1.72E-02	1410563	1410563	1983604	2115844	3.89E-03	3.89E-03	3.62E-03	3.58E-03
5.22	0.27	34	2.21E-02	1449436	1449436	2038270	2174154	3.87E-03	3.87E-03	3.60E-03	3.56E-03
5.37	0.28	46	2.83E-02	1491087	1491087	2096841	2236630	3.84E-03	3.84E-03	3.58E-03	3.54E-03
5.52	0.28	60	3.49E-02	1532737	1532737	2155412	2299106	3.82E-03	3.82E-03	3.56E-03	3.52E-03
5.67	0.29	73	4.02E-02	1574388	1574388	2213983	2361582	3.80E-03	3.80E-03	3.54E-03	3.50E-03
5.82	0.30	83	4.34E-02	1616038	1616038	2272554	2424057	3.78E-03	3.78E-03	3.53E-03	3.48E-03
5.97	0.31	90	4.47E-02	1657689	1657689	2331125	2486533	3.76E-03	3.76E-03	3.51E-03	3.46E-03
6.11	0.32	94	4.46E-02	1696562	1696562	2385791	2544844	3.74E-03	3.74E-03	3.49E-03	3.45E-03
6.26	0.32	95	4.30E-02	1738213	1738213	2444362	2607319	3.72E-03	3.72E-03	3.47E-03	3.43E-03
6.57	0.34	91	3.74E-02	1824291	1824291	2565409	2736436	3.69E-03	3.69E-03	3.44E-03	3.40E-03
6.87	0.35	83	3.12E-02	1907591	1907591	2682551	2861387	3.65E-03	3.65E-03	3.41E-03	3.37E-03
7.16	0.37	75	2.59E-02	1988116	1988116	2795788	2982174	3.62E-03	3.62E-03	3.38E-03	3.34E-03
7.46	0.38	67	2.13E-02	2071417	2071417	2912930	3107125	3.59E-03	3.59E-03	3.36E-03	3.31E-03
7.76	0.40	62	1.82E-02	2154718	2154718	3030072	3232076	3.56E-03	3.56E-03	3.33E-03	3.29E-03
8.05	0.42	58	1.59E-02	2235242	2235242	3143309	3352863	3.54E-03	3.54E-03	3.31E-03	3.27E-03
8.35	0.43	56	1.42E-02	2318543	2318543	3260451	3477814	3.51E-03	3.51E-03	3.28E-03	3.24E-03
8.95	0.46	55	1.22E-02	2485145	2485145	3494735	3727717	3.46E-03	3.46E-03	3.24E-03	3.20E-03
9.55	0.49	56	1.09E-02	2651747	2651747	3729019	3977620	3.42E-03	3.42E-03	3.20E-03	3.16E-03
10.14	0.52	58	1.00E-02	2815572	2815572	3959398	4223358	3.38E-03	3.38E-03	3.16E-03	3.12E-03
10.73	0.55	60	9.23E-03	2979397	2979397	4189777	4469095	3.34E-03	3.34E-03	3.13E-03	3.09E-03
11.34	0.58	63	8.68E-03	3148775	3148775	4427966	4723163	3.31E-03	3.31E-03	3.10E-03	3.06E-03
11.93	0.62	67	8.34E-03	3312601	3312601	4658345	4968901	3.27E-03	3.27E-03	3.07E-03	3.03E-03
12.52	0.65	70	7.91E-03	3476426	3476426	4888724	5214639	3.24E-03	3.24E-03	3.04E-03	3.00E-03
13.13	0.68	75	7.71E-03	3645804	3645804	5126912	5468707	3.21E-03	3.21E-03	3.01E-03	2.98E-03
14.33	0.74	84	7.25E-03	3979008	3979008	5595480	5968512	3.16E-03	3.16E-03	2.97E-03	2.93E-03
15.51	0.80	93	6.85E-03	4306659	4306659	6056239	6459988	3.11E-03	3.11E-03	2.92E-03	2.89E-03
16.71	0.86	103	6.54E-03	4639862	4639862	6524806	6959793	3.07E-03	3.07E-03	2.88E-03	2.85E-03
17.91	0.92	113	6.24E-03	4973066	4973066	6993374	7459599	3.03E-03	3.03E-03	2.85E-03	2.81E-03
19.09	0.98	123	5.98E-03	5300716	5300716	7454132	7951075	2.99E-03	2.99E-03	2.81E-03	2.78E-03
20.29	1.05	135	5.81E-03	5633920	5633920	7922700	8450880	2.96E-03	2.96E-03	2.78E-03	2.75E-03
21.49	1.11	147	5.64E-03	5967124	5967124	8391268	8950686	2.93E-03	2.93E-03	2.76E-03	2.72E-03
22.68	1.17	161	5.55E-03	6297551	6297551	8855931	9446326	2.90E-03	2.90E-03	2.73E-03	2.70E-03
23.87	1.23	174	5.41E-03	6627978	6627978	9320594	9941967	2.87E-03	2.87E-03	2.71E-03	2.67E-03

Table 14. Modified Hughes resistance calculations for a sectionalized hull analysis of the SLICE.

Frictional Resistance of Model Components				Summed	Equivalent	Model	Model Strut	Model Strut	Sum
RFOm (lbf.)				Σ RFOm	Frictional	Equivalent	Form	Form Drag	RFO+Rform.strut
Fwd Strut	Aft Strut	Fwd Pod	Aft Pod	(lbf.)	CFOm	Reynolds #	Cform.strut	(lbf.)	(lbf.)
0.48	0.48	0.57	0.58	2.10	4.17E-03	1019383	2.80E-04	0.06	2.17
0.56	0.56	0.66	0.68	2.47	4.09E-03	1114906	2.80E-04	0.07	2.54
0.66	0.66	0.78	0.80	2.90	4.01E-03	1220668	2.80E-04	0.09	2.99
0.76	0.76	0.90	0.92	3.35	3.94E-03	1323023	2.80E-04	0.10	3.45
0.87	0.86	1.03	1.05	3.81	3.88E-03	1421969	2.80E-04	0.12	3.93
0.98	0.98	1.16	1.19	4.31	3.83E-03	1524331	2.80E-04	0.14	4.45
1.11	1.10	1.31	1.34	4.87	3.77E-03	1630107	2.80E-04	0.16	5.02
1.24	1.23	1.46	1.50	5.43	3.73E-03	1732475	2.80E-04	0.18	5.60
1.30	1.29	1.54	1.57	5.70	3.71E-03	1780248	2.80E-04	0.19	5.89
1.37	1.36	1.62	1.65	6.00	3.68E-03	1831433	2.80E-04	0.20	6.19
1.44	1.43	1.70	1.74	6.30	3.66E-03	1882619	2.80E-04	0.21	6.51
1.51	1.50	1.78	1.82	6.61	3.64E-03	1933806	2.80E-04	0.22	6.83
1.58	1.57	1.87	1.91	6.93	3.62E-03	1984994	2.80E-04	0.23	7.16
1.65	1.64	1.96	2.00	7.25	3.60E-03	2036181	2.80E-04	0.25	7.50
1.72	1.71	2.04	2.09	7.56	3.59E-03	2083957	2.80E-04	0.26	7.82
1.80	1.79	2.13	2.18	7.90	3.57E-03	2135146	2.80E-04	0.27	8.17
1.96	1.95	2.32	2.38	8.61	3.54E-03	2240939	2.80E-04	0.30	8.91
2.13	2.11	2.52	2.58	9.33	3.50E-03	2343320	2.80E-04	0.32	9.66
2.29	2.27	2.71	2.78	10.06	3.48E-03	2442291	2.80E-04	0.35	10.41
2.47	2.45	2.92	2.99	10.83	3.45E-03	2544676	2.80E-04	0.38	11.21
2.65	2.63	3.14	3.21	11.62	3.42E-03	2647063	2.80E-04	0.41	12.04
2.83	2.81	3.35	3.43	12.42	3.40E-03	2746039	2.80E-04	0.45	12.86
3.02	3.00	3.58	3.67	13.27	3.37E-03	2848429	2.80E-04	0.48	13.75
3.42	3.40	4.06	4.16	15.03	3.33E-03	3053214	2.80E-04	0.55	15.59
3.85	3.82	4.57	4.67	16.90	3.28E-03	3258004	2.80E-04	0.63	17.53
4.28	4.25	5.09	5.21	18.84	3.25E-03	3459386	2.80E-04	0.71	19.54
4.74	4.71	5.64	5.77	20.87	3.21E-03	3660773	2.80E-04	0.79	21.66
5.24	5.21	6.23	6.38	23.06	3.18E-03	3868991	2.80E-04	0.88	23.94
5.75	5.71	6.83	6.99	25.28	3.15E-03	4070386	2.80E-04	0.98	26.26
6.27	6.23	7.46	7.64	27.59	3.12E-03	4271785	2.80E-04	1.08	28.66
6.83	6.79	8.13	8.32	30.07	3.09E-03	4480015	2.80E-04	1.19	31.25
8.00	7.95	9.53	9.76	35.23	3.04E-03	4889658	2.80E-04	1.41	36.65
9.24	9.17	11.00	11.27	40.67	3.00E-03	5292487	2.80E-04	1.65	42.33
10.57	10.50	12.59	12.90	46.57	2.95E-03	5702154	2.80E-04	1.92	48.49
11.99	11.91	14.29	14.64	52.82	2.92E-03	6111833	2.80E-04	2.21	55.02
13.46	13.37	16.05	16.44	59.31	2.88E-03	6514693	2.80E-04	2.51	61.82
15.03	14.93	17.93	18.37	66.27	2.85E-03	6924390	2.80E-04	2.83	69.10
16.69	16.57	19.91	20.40	73.57	2.82E-03	7334096	2.80E-04	3.18	76.75
18.41	18.28	21.97	22.51	81.16	2.80E-03	7740395	2.80E-04	3.54	84.70
20.20	20.06	24.11	24.71	89.08	2.77E-03	8146702	2.80E-04	3.92	93.00

Table 14. Modified Hughes resistance calculations for a sectionalized hull analysis of the SLICE.

Model	r' = 1.87	Model	Model	Model Pod	Model Pod	Model	Model	Model	Model
(Frictional + Form)		Form Drag	Form	Form Drag	Form	Wave Making	Wave Making	Residual	Residual
(r'*C.equiv)	R(Rn)m (lbf.)	(lbf.)	Cform.m	(lbf.)	Cform.pod	RWMm (lbf.)	CWMm	RRm (lbf.)	CRm
8.03E-03	4.05	1.95	3.86E-03	1.88	6.61E-03	0.95	1.88E-03	2.90	5.74E-03
7.88E-03	4.75	2.28	3.79E-03	2.21	6.49E-03	0.25	4.10E-04	2.53	4.20E-03
7.73E-03	5.59	2.69	3.72E-03	2.60	6.37E-03	0.41	5.67E-04	3.10	4.28E-03
7.60E-03	6.46	3.11	3.66E-03	3.00	6.26E-03	0.54	6.39E-04	3.65	4.30E-03
7.49E-03	7.35	3.54	3.61E-03	3.42	6.17E-03	7.65	7.80E-03	11.19	1.14E-02
7.38E-03	8.33	4.01	3.56E-03	3.87	6.09E-03	15.67	1.39E-02	19.69	1.75E-02
7.28E-03	9.39	4.53	3.51E-03	4.37	6.00E-03	10.61	8.23E-03	15.13	1.17E-02
7.20E-03	10.48	5.05	3.47E-03	4.88	5.93E-03	14.52	9.97E-03	19.57	1.34E-02
7.16E-03	11.01	5.31	3.45E-03	5.12	5.90E-03	22.99	1.50E-02	28.30	1.84E-02
7.12E-03	11.58	5.59	3.43E-03	5.39	5.87E-03	34.42	2.11E-02	40.00	2.46E-02
7.08E-03	12.17	5.87	3.41E-03	5.66	5.83E-03	47.83	2.78E-02	53.70	3.12E-02
7.04E-03	12.77	6.16	3.40E-03	5.94	5.80E-03	60.23	3.32E-02	66.39	3.66E-02
7.00E-03	13.39	6.46	3.38E-03	6.23	5.77E-03	69.61	3.64E-02	76.07	3.98E-02
6.97E-03	14.02	6.77	3.36E-03	6.52	5.74E-03	75.98	3.78E-02	82.75	4.11E-02
6.94E-03	14.62	7.06	3.35E-03	6.80	5.72E-03	79.38	3.77E-02	86.44	4.10E-02
6.90E-03	15.27	7.37	3.33E-03	7.10	5.69E-03	79.73	3.61E-02	87.10	3.94E-02
6.84E-03	16.66	8.05	3.30E-03	7.75	5.64E-03	74.34	3.05E-02	82.39	3.38E-02
6.78E-03	18.06	8.73	3.28E-03	8.40	5.59E-03	64.94	2.44E-02	73.67	2.77E-02
6.73E-03	19.46	9.41	3.25E-03	9.05	5.54E-03	55.54	1.92E-02	64.94	2.24E-02
6.67E-03	20.96	10.14	3.23E-03	9.75	5.50E-03	46.04	1.47E-02	56.17	1.79E-02
6.62E-03	22.51	10.89	3.20E-03	10.47	5.46E-03	39.49	1.16E-02	50.38	1.48E-02
6.58E-03	24.06	11.64	3.18E-03	11.19	5.42E-03	33.94	9.28E-03	45.58	1.25E-02
6.53E-03	25.70	12.44	3.16E-03	11.96	5.38E-03	30.30	7.70E-03	42.73	1.09E-02
6.45E-03	29.15	14.11	3.12E-03	13.56	5.31E-03	25.85	5.72E-03	39.97	8.84E-03
6.37E-03	32.78	15.88	3.09E-03	15.25	5.25E-03	23.22	4.51E-03	39.10	7.60E-03
6.30E-03	36.55	17.71	3.05E-03	17.00	5.19E-03	21.45	3.70E-03	39.16	6.75E-03
6.23E-03	40.50	19.63	3.02E-03	18.84	5.14E-03	19.50	3.00E-03	39.13	6.02E-03
6.17E-03	44.78	21.72	2.99E-03	20.83	5.08E-03	18.22	2.51E-03	39.94	5.50E-03
6.11E-03	49.10	23.82	2.97E-03	22.84	5.04E-03	17.90	2.23E-03	41.72	5.19E-03
6.06E-03	53.60	26.02	2.94E-03	24.94	4.99E-03	16.40	1.85E-03	42.41	4.79E-03
6.01E-03	58.45	28.38	2.92E-03	27.19	4.95E-03	16.55	1.70E-03	44.93	4.62E-03
5.91E-03	68.53	33.29	2.87E-03	31.88	4.87E-03	15.47	1.34E-03	48.77	4.21E-03
5.83E-03	79.15	38.48	2.83E-03	36.82	4.81E-03	13.85	1.02E-03	52.33	3.85E-03
5.75E-03	90.67	44.10	2.80E-03	42.18	4.74E-03	12.33	7.83E-04	56.43	3.58E-03
5.68E-03	102.89	50.08	2.77E-03	47.87	4.68E-03	10.11	5.58E-04	60.18	3.32E-03
5.62E-03	115.60	56.29	2.74E-03	53.78	4.63E-03	7.40	3.60E-04	63.69	3.10E-03
5.56E-03	129.22	62.95	2.71E-03	60.12	4.58E-03	5.78	2.49E-04	68.73	2.96E-03
5.51E-03	143.52	69.95	2.68E-03	66.77	4.54E-03	3.48	1.33E-04	73.43	2.82E-03
5.46E-03	158.38	77.22	2.66E-03	73.69	4.50E-03	2.62	9.01E-05	79.84	2.75E-03
5.41E-03	173.91	84.83	2.64E-03	80.91	4.46E-03	0.09	2.69E-06	84.92	2.64E-03

Table 14. Modified Hughes resistance calculations for a sectionalized hull analysis of the SLICE.

Ship	Ship	Ship	Reynolds #'s for Ship Component Lengths				Ship Hughes Coefficients			
Velocity	Velocity	Froude	L=24.00'	L=24.00'	L=33.75'	L=36.00'	CFOs (no form factor)			
(fps)	(kts.)	#	Fwd Strut	Aft Strut	Fwd Pod	Aft Pod	Fwd Strut	Aft Strut	Fwd Pod	Aft Pod
8.46	5.01	0.15	15868275	15868275	22314762	23802412	2.47E-03	2.47E-03	2.33E-03	2.31E-03
9.25	5.48	0.17	17354267	17354267	24404438	26031401	2.43E-03	2.43E-03	2.30E-03	2.28E-03
10.13	6.00	0.18	18999473	18999473	26718009	28499209	2.40E-03	2.40E-03	2.27E-03	2.24E-03
10.97	6.50	0.20	20591608	20591608	28956948	30887411	2.36E-03	2.36E-03	2.24E-03	2.21E-03
11.79	6.98	0.21	22130671	22130671	31121256	33196007	2.34E-03	2.34E-03	2.21E-03	2.19E-03
12.64	7.49	0.23	23722806	23722806	33360195	35584208	2.31E-03	2.31E-03	2.19E-03	2.17E-03
13.52	8.01	0.25	25368011	25368011	35673766	38052017	2.29E-03	2.29E-03	2.16E-03	2.14E-03
14.37	8.51	0.26	26960146	26960146	37912705	40440219	2.26E-03	2.26E-03	2.14E-03	2.12E-03
14.76	8.74	0.27	27703142	27703142	38957544	41554713	2.25E-03	2.25E-03	2.13E-03	2.11E-03
15.19	8.99	0.28	28499209	28499209	40077013	42748814	2.24E-03	2.24E-03	2.13E-03	2.10E-03
15.61	9.24	0.28	29295277	29295277	41196483	43942915	2.23E-03	2.23E-03	2.12E-03	2.09E-03
16.04	9.50	0.29	30091344	30091344	42315953	45137016	2.22E-03	2.22E-03	2.11E-03	2.09E-03
16.46	9.75	0.30	30887411	30887411	43435422	46331117	2.21E-03	2.21E-03	2.10E-03	2.08E-03
16.89	10.00	0.31	31683479	31683479	44554892	47525218	2.21E-03	2.21E-03	2.09E-03	2.07E-03
17.28	10.23	0.32	32426475	32426475	45599730	48639712	2.20E-03	2.20E-03	2.08E-03	2.06E-03
17.71	10.48	0.32	33222542	33222542	46719200	49833813	2.19E-03	2.19E-03	2.08E-03	2.05E-03
18.58	11.00	0.34	34867748	34867748	49032770	52301622	2.17E-03	2.17E-03	2.06E-03	2.04E-03
19.43	11.51	0.35	36459882	36459882	51271710	54689824	2.16E-03	2.16E-03	2.05E-03	2.03E-03
20.25	11.99	0.37	37998946	37998946	53436018	56998419	2.14E-03	2.14E-03	2.03E-03	2.01E-03
21.10	12.49	0.38	39591080	39591080	55674957	59386621	2.13E-03	2.13E-03	2.02E-03	2.00E-03
21.95	13.00	0.40	41183215	41183215	57913896	61774823	2.12E-03	2.12E-03	2.01E-03	1.99E-03
22.77	13.48	0.42	42722279	42722279	60078204	64083418	2.10E-03	2.10E-03	2.00E-03	1.98E-03
23.62	13.98	0.43	44314413	44314413	62317144	66471620	2.09E-03	2.09E-03	1.99E-03	1.97E-03
25.31	14.99	0.46	47498682	47498682	66795022	71248024	2.07E-03	2.07E-03	1.97E-03	1.95E-03
27.01	15.99	0.49	50682952	50682952	71272901	76024427	2.05E-03	2.05E-03	1.95E-03	1.93E-03
28.68	16.98	0.52	53814150	53814150	75676148	80721224	2.03E-03	2.03E-03	1.93E-03	1.91E-03
30.35	17.97	0.55	56945348	56945348	80079395	85418022	2.01E-03	2.01E-03	1.91E-03	1.90E-03
32.07	18.99	0.58	60182688	60182688	84631905	90274032	2.00E-03	2.00E-03	1.90E-03	1.88E-03
33.74	19.98	0.62	63313886	63313886	89035152	94970829	1.98E-03	1.98E-03	1.88E-03	1.87E-03
35.41	20.97	0.65	66445084	66445084	93438400	99667626	1.97E-03	1.97E-03	1.87E-03	1.85E-03
37.14	21.99	0.68	69682425	69682425	97990909	104523637	1.95E-03	1.95E-03	1.86E-03	1.84E-03
40.53	24.00	0.74	76050963	76050963	106946667	114076444	1.93E-03	1.93E-03	1.83E-03	1.82E-03
43.87	25.98	0.80	82313359	82313359	115753161	123470039	1.91E-03	1.91E-03	1.81E-03	1.80E-03
47.26	27.98	0.86	88681897	88681897	124708918	133022846	1.88E-03	1.88E-03	1.79E-03	1.78E-03
50.66	29.99	0.92	95050436	95050436	133664675	142575654	1.87E-03	1.87E-03	1.78E-03	1.76E-03
53.99	31.97	0.98	101312832	101312832	142471170	151969248	1.85E-03	1.85E-03	1.76E-03	1.74E-03
57.39	33.98	1.05	107681370	107681370	151426927	161522056	1.83E-03	1.83E-03	1.74E-03	1.73E-03
60.78	35.99	1.11	114049909	114049909	160382684	171074863	1.82E-03	1.82E-03	1.73E-03	1.72E-03
64.15	37.98	1.17	120365376	120365376	169263810	180548064	1.80E-03	1.80E-03	1.72E-03	1.70E-03
67.51	39.98	1.23	126680843	126680843	178144936	190021265	1.79E-03	1.79E-03	1.71E-03	1.69E-03

Table 14. Modified Hughes resistance calculations for a sectionalized hull analysis of the SLICE.

Frictional Resistance of Ship Components				Summed	Equivalent	Ship	Ship Strut	Ship Strut	Sum
RFOs (lbf.)				Σ RFOs	Frictional	Equivalent	Form	Form Drag	RFO+Rform.strut
Fwd Strut	Aft Strut	Fwd Pod	Aft Pod	(lbf.)	CFOs	Reynolds #	Cform.strut	(lbf.)	(lbf.)
143	142	172	176	633	2.39E-03	19510913	2.80E-04	32	666
169	168	202	208	746	2.35E-03	21338704	2.80E-04	39	785
199	198	239	245	881	2.32E-03	23362384	2.80E-04	46	928
231	229	277	284	1022	2.29E-03	25320833	2.80E-04	54	1076
264	262	317	325	1167	2.26E-03	27214042	2.80E-04	63	1230
300	297	360	369	1326	2.23E-03	29172574	2.80E-04	72	1398
339	336	407	418	1500	2.21E-03	31196429	2.80E-04	83	1583
379	376	455	467	1678	2.19E-03	33155034	2.80E-04	93	1771
398	396	479	491	1764	2.18E-03	34069060	2.80E-04	99	1863
420	417	504	518	1859	2.17E-03	35048382	2.80E-04	104	1963
441	438	531	545	1955	2.16E-03	36027711	2.80E-04	110	2066
464	461	558	572	2054	2.15E-03	37007048	2.80E-04	116	2171
487	483	585	601	2156	2.14E-03	37986392	2.80E-04	123	2278
510	506	613	629	2259	2.13E-03	38965742	2.80E-04	129	2388
532	529	640	657	2358	2.13E-03	39879809	2.80E-04	135	2493
557	553	669	687	2466	2.12E-03	40859172	2.80E-04	142	2608
608	604	732	751	2696	2.10E-03	42883210	2.80E-04	156	2852
661	656	795	816	2927	2.09E-03	44841980	2.80E-04	171	3098
713	708	858	881	3159	2.08E-03	46735479	2.80E-04	186	3345
769	764	926	950	3408	2.06E-03	48694293	2.80E-04	201	3609
827	821	996	1022	3665	2.05E-03	50653128	2.80E-04	218	3883
885	879	1065	1094	3922	2.04E-03	52546687	2.80E-04	235	4157
947	940	1140	1170	4197	2.03E-03	54505560	2.80E-04	252	4449
1076	1069	1296	1330	4771	2.01E-03	58423360	2.80E-04	290	5061
1213	1205	1461	1500	5379	1.99E-03	62341227	2.80E-04	330	5709
1355	1346	1633	1676	6010	1.97E-03	66193858	2.80E-04	372	6382
1504	1494	1813	1862	6673	1.95E-03	70046545	2.80E-04	417	7090
1666	1655	2009	2062	7392	1.94E-03	74029887	2.80E-04	465	7857
1830	1817	2207	2266	8120	1.92E-03	77882679	2.80E-04	515	8635
2001	1987	2413	2478	8879	1.91E-03	81735518	2.80E-04	567	9447
2185	2170	2636	2706	9697	1.89E-03	85719008	2.80E-04	624	10321
2569	2551	3100	3183	11403	1.87E-03	93555512	2.80E-04	743	12147
2974	2954	3590	3687	13206	1.85E-03	101261561	2.80E-04	871	14076
3415	3391	4123	4234	15163	1.83E-03	109098365	2.80E-04	1011	16174
3883	3856	4690	4816	17246	1.81E-03	116935301	2.80E-04	1161	18407
4371	4341	5280	5423	19415	1.79E-03	124641742	2.80E-04	1319	20734
4894	4861	5914	6074	21742	1.78E-03	132478913	2.80E-04	1490	23232
5445	5407	6580	6759	24191	1.76E-03	140316191	2.80E-04	1672	25863
6018	5976	7274	7471	26739	1.75E-03	148088257	2.80E-04	1862	28601
6617	6572	8000	8217	29406	1.74E-03	155860415	2.80E-04	2062	31468

Table 14. Modified Hughes resistance calculations for a sectionalized hull analysis of the SLICE.

Ship (Frictional + Form) (r'*C.equiv)	r' = 1.87 (lbf.)	Ship Form Drag (lbf.)	Ship Form Cform.s	Ship Pod Form Drag (lbf.)	Ship Pod Form Cform.pod	Ship Wave Making CWMs	Ship Wave Making RWMs (lbf.)
4.69E-03	1245	611	2.30E-03	579	3.86E-03	1.88E-03	500
4.62E-03	1468	722	2.27E-03	683	3.81E-03	4.10E-04	130
4.56E-03	1735	854	2.24E-03	807	3.76E-03	5.67E-04	216
4.50E-03	2013	991	2.22E-03	936	3.71E-03	6.39E-04	286
4.45E-03	2300	1133	2.19E-03	1070	3.67E-03	7.80E-03	4026
4.41E-03	2615	1289	2.17E-03	1216	3.63E-03	1.39E-02	8248
4.36E-03	2960	1460	2.15E-03	1377	3.59E-03	8.23E-03	5582
4.32E-03	3312	1634	2.13E-03	1541	3.56E-03	9.97E-03	7641
4.30E-03	3483	1719	2.12E-03	1621	3.55E-03	1.50E-02	12100
4.29E-03	3671	1812	2.12E-03	1708	3.53E-03	2.11E-02	18112
4.27E-03	3863	1907	2.11E-03	1797	3.52E-03	2.78E-02	25169
4.25E-03	4059	2005	2.10E-03	1889	3.50E-03	3.32E-02	31693
4.24E-03	4260	2105	2.09E-03	1982	3.49E-03	3.64E-02	36631
4.22E-03	4466	2207	2.08E-03	2078	3.48E-03	3.78E-02	39984
4.20E-03	4662	2304	2.08E-03	2169	3.47E-03	3.77E-02	41773
4.19E-03	4876	2410	2.07E-03	2269	3.45E-03	3.61E-02	41956
4.16E-03	5333	2637	2.06E-03	2481	3.43E-03	3.05E-02	39118
4.13E-03	5793	2866	2.04E-03	2695	3.41E-03	2.44E-02	34172
4.11E-03	6255	3096	2.03E-03	2910	3.39E-03	1.92E-02	29225
4.08E-03	6750	3342	2.02E-03	3140	3.37E-03	1.47E-02	24226
4.06E-03	7262	3597	2.01E-03	3379	3.35E-03	1.16E-02	20780
4.04E-03	7774	3851	2.00E-03	3617	3.33E-03	9.28E-03	17862
4.02E-03	8320	4123	1.99E-03	3871	3.31E-03	7.70E-03	15943
3.98E-03	9464	4693	1.97E-03	4403	3.28E-03	5.72E-03	13605
3.94E-03	10676	5297	1.96E-03	4967	3.25E-03	4.51E-03	12217
3.91E-03	11935	5925	1.94E-03	5552	3.22E-03	3.70E-03	11288
3.88E-03	13258	6585	1.93E-03	6168	3.20E-03	3.00E-03	10262
3.85E-03	14693	7301	1.91E-03	6836	3.17E-03	2.51E-03	9590
3.82E-03	16147	8028	1.90E-03	7512	3.15E-03	2.23E-03	9420
3.79E-03	17665	8786	1.89E-03	8218	3.13E-03	1.85E-03	8629
3.77E-03	19301	9603	1.88E-03	8979	3.11E-03	1.70E-03	8712
3.72E-03	22714	11311	1.85E-03	10568	3.07E-03	1.34E-03	8142
3.68E-03	26323	13117	1.84E-03	12246	3.04E-03	1.02E-03	7287
3.65E-03	30245	15082	1.82E-03	14071	3.01E-03	7.83E-04	6489
3.61E-03	34421	17175	1.80E-03	16014	2.98E-03	5.58E-04	5318
3.58E-03	38772	19357	1.79E-03	18038	2.95E-03	3.60E-04	3892
3.55E-03	43444	21702	1.78E-03	20212	2.93E-03	2.49E-04	3043
3.53E-03	48363	24172	1.76E-03	22500	2.91E-03	1.33E-04	1830
3.50E-03	53484	26745	1.75E-03	24883	2.89E-03	9.01E-05	1377
3.48E-03	58845	29440	1.74E-03	27377	2.87E-03	2.69E-06	46

Table 14. Modified Hughes resistance calculations for a sectionalized hull analysis of the SLICE.

Ship Residual RRs (lbf.)	Ship Residual CRs	Ship Allowance CA	Ship Allowance RAs (lbf.)	Ship Total Resistance RTs(lbf.)	Ship Total CTs		EHP (hp)	SHP (hp)
1112	4.19E-03	0.0005	133	1878	7.07E-03		29	40
852	2.68E-03	0.0005	159	1757	5.53E-03		30	40
1070	2.81E-03	0.0005	190	2141	5.63E-03		39	54
1277	2.86E-03	0.0005	224	2522	5.64E-03		50	69
5159	9.99E-03	0.0005	258	6584	1.27E-02		141	193
9537	1.61E-02	0.0005	297	11159	1.88E-02		257	351
7041	1.04E-02	0.0005	339	8881	1.31E-02		218	299
9275	1.21E-02	0.0005	383	11336	1.48E-02		296	406
13819	1.71E-02	0.0005	405	15988	1.98E-02		429	588
19924	2.33E-02	0.0005	428	22211	2.59E-02		613	840
27076	2.99E-02	0.0005	452	29484	3.26E-02		837	1147
33697	3.53E-02	0.0005	477	36229	3.79E-02		1056	1447
38736	3.85E-02	0.0005	503	41394	4.11E-02		1239	1697
42190	3.99E-02	0.0005	529	44979	4.25E-02		1381	1892
44078	3.98E-02	0.0005	554	46990	4.24E-02		1476	2023
44366	3.81E-02	0.0005	582	47414	4.07E-02		1526	2091
41756	3.26E-02	0.0005	641	45092	3.52E-02		1524	2087
37038	2.64E-02	0.0005	701	40666	2.90E-02		1437	1968
32321	2.12E-02	0.0005	761	36241	2.38E-02		1334	1828
27568	1.67E-02	0.0005	826	31802	1.92E-02		1220	1671
24376	1.36E-02	0.0005	894	28936	1.62E-02		1155	1582
21713	1.13E-02	0.0005	962	26598	1.38E-02		1101	1508
20066	9.69E-03	0.0005	1035	25298	1.22E-02		1086	1488
18298	7.69E-03	0.0005	1189	24259	1.02E-02		1117	1529
17515	6.47E-03	0.0005	1354	24248	8.95E-03		1191	1631
17213	5.64E-03	0.0005	1527	24750	8.11E-03		1291	1768
16847	4.93E-03	0.0005	1710	25229	7.38E-03		1392	1907
16891	4.42E-03	0.0005	1910	26193	6.86E-03		1527	2092
17448	4.13E-03	0.0005	2113	27681	6.55E-03		1698	2326
17415	3.74E-03	0.0005	2328	28622	6.15E-03		1843	2524
18315	3.58E-03	0.0005	2560	30572	5.97E-03		2064	2828
19453	3.19E-03	0.0005	3049	33905	5.56E-03		2499	3423
20404	2.86E-03	0.0005	3572	37182	5.20E-03		2966	4063
21571	2.60E-03	0.0005	4146	40881	4.93E-03		3513	4812
22493	2.36E-03	0.0005	4763	44502	4.67E-03		4099	5615
23250	2.15E-03	0.0005	5411	48076	4.44E-03		4720	6465
24745	2.02E-03	0.0005	6113	52600	4.30E-03		5488	7518
26002	1.90E-03	0.0005	6858	57051	4.16E-03		6305	8637
28121	1.84E-03	0.0005	7638	62499	4.09E-03		7289	9986
29485	1.74E-03	0.0005	8461	67351	3.98E-03		8268	11326

Table 14. Modified Hughes resistance calculations for a sectionalized hull analysis of the SLICE.

Model Rn Scaled (lbf.)	Model Rn Scaled C	Model Fn RWMm (lbf.)	Model Fn CWMm C	Model Strut Form (lbf.)	Constant Strut Form C	Model Fn (lbf.)	Model Fn+Const Scaled C	Ship Rn Scaled (lbf.)	Ship Rn Scaled C	Ship Fn RWMs (lbf.)	Ship Fn CWMs C	Ship Strut Form (lbf.)	Constant Strut Form C	Ship Fn Scaled (lbf.)	Ship Fn+Const Scaled C
3.99	7.90E-03	0.95	1.88E-03	0.06	2.80E-04	1.01	2.01E-03	1212	4.57E-03	500	1.88E-03	32	2.80E-04	533	2.01E-03
4.68	7.75E-03	0.25	4.10E-04	0.07	2.80E-04	0.32	5.32E-04	1429	4.50E-03	130	4.10E-04	39	2.80E-04	169	5.32E-04
5.50	7.61E-03	0.41	5.67E-04	0.09	2.80E-04	0.50	6.89E-04	1689	4.44E-03	216	5.67E-04	46	2.80E-04	262	6.89E-04
6.35	7.48E-03	0.54	6.39E-04	0.10	2.80E-04	0.65	7.61E-04	1958	4.38E-03	286	6.39E-04	54	2.80E-04	340	7.61E-04
7.23	7.37E-03	7.65	7.80E-03	0.12	2.80E-04	7.77	7.92E-03	2237	4.33E-03	4026	7.80E-03	63	2.80E-04	4089	7.92E-03
8.19	7.26E-03	15.67	1.39E-02	0.14	2.80E-04	15.81	1.40E-02	2542	4.28E-03	8248	1.39E-02	72	2.80E-04	8320	1.40E-02
9.24	7.16E-03	10.61	8.23E-03	0.16	2.80E-04	10.76	8.35E-03	2877	4.24E-03	5582	8.23E-03	83	2.80E-04	5664	8.35E-03
10.30	7.07E-03	14.52	9.97E-03	0.18	2.80E-04	14.70	1.01E-02	3219	4.20E-03	7641	9.97E-03	93	2.80E-04	7734	1.01E-02
10.82	7.03E-03	22.99	1.50E-02	0.19	2.80E-04	23.18	1.51E-02	3385	4.18E-03	12100	1.50E-02	99	2.80E-04	12199	1.51E-02
11.38	6.99E-03	34.42	2.11E-02	0.20	2.80E-04	34.62	2.13E-02	3566	4.16E-03	18112	2.11E-02	104	2.80E-04	18216	2.13E-02
11.96	6.96E-03	47.83	2.78E-02	0.21	2.80E-04	48.04	2.79E-02	3752	4.15E-03	25169	2.78E-02	110	2.80E-04	25279	2.79E-02
12.55	6.92E-03	60.23	3.32E-02	0.22	2.80E-04	60.45	3.33E-02	3943	4.13E-03	31693	3.32E-02	116	2.80E-04	31809	3.33E-02
13.16	6.88E-03	69.61	3.64E-02	0.23	2.80E-04	69.84	3.65E-02	4138	4.11E-03	36631	3.64E-02	123	2.80E-04	36753	3.65E-02
13.77	6.85E-03	75.98	3.78E-02	0.25	2.80E-04	76.23	3.79E-02	4337	4.10E-03	39984	3.78E-02	129	2.80E-04	40113	3.79E-02
14.36	6.82E-03	79.38	3.77E-02	0.26	2.80E-04	79.64	3.78E-02	4527	4.08E-03	41773	3.77E-02	135	2.80E-04	41909	3.78E-02
15.00	6.78E-03	79.73	3.61E-02	0.27	2.80E-04	80.00	3.62E-02	4734	4.07E-03	41956	3.61E-02	142	2.80E-04	42097	3.62E-02
16.37	6.72E-03	74.34	3.05E-02	0.30	2.80E-04	74.63	3.06E-02	5177	4.04E-03	39118	3.05E-02	156	2.80E-04	39274	3.06E-02
17.74	6.66E-03	64.94	2.44E-02	0.32	2.80E-04	65.26	2.45E-02	5622	4.01E-03	34172	2.44E-02	171	2.80E-04	34343	2.45E-02
19.11	6.61E-03	55.54	1.92E-02	0.35	2.80E-04	55.89	1.93E-02	6069	3.99E-03	29225	1.92E-02	186	2.80E-04	29411	1.93E-02
20.58	6.55E-03	46.04	1.47E-02	0.38	2.80E-04	46.42	1.48E-02	6548	3.96E-03	24226	1.47E-02	201	2.80E-04	24428	1.48E-02
22.10	6.50E-03	39.49	1.16E-02	0.41	2.80E-04	39.90	1.17E-02	7044	3.94E-03	20780	1.16E-02	218	2.80E-04	20998	1.17E-02
23.61	6.46E-03	33.94	9.28E-03	0.45	2.80E-04	34.39	9.40E-03	7539	3.92E-03	17862	9.28E-03	235	2.80E-04	18097	9.40E-03
25.22	6.41E-03	30.30	7.70E-03	0.48	2.80E-04	30.78	7.82E-03	8068	3.90E-03	15943	7.70E-03	252	2.80E-04	16195	7.82E-03
28.59	6.33E-03	25.85	5.72E-03	0.55	2.80E-04	26.41	5.84E-03	9174	3.86E-03	13605	5.72E-03	290	2.80E-04	13895	5.84E-03
32.16	6.25E-03	23.22	4.51E-03	0.63	2.80E-04	23.84	4.63E-03	10346	3.82E-03	12217	4.51E-03	330	2.80E-04	12547	4.63E-03
35.84	6.18E-03	21.45	3.70E-03	0.71	2.80E-04	22.16	3.82E-03	11562	3.79E-03	11288	3.70E-03	372	2.80E-04	11661	3.82E-03
39.71	6.11E-03	19.50	3.00E-03	0.79	2.80E-04	20.29	3.12E-03	12841	3.76E-03	10262	3.00E-03	417	2.80E-04	10679	3.12E-03
43.89	6.05E-03	18.22	2.51E-03	0.88	2.80E-04	19.11	2.63E-03	14228	3.73E-03	9590	2.51E-03	465	2.80E-04	10055	2.63E-03
48.12	5.99E-03	17.90	2.23E-03	0.98	2.80E-04	18.88	2.35E-03	15632	3.70E-03	9420	2.23E-03	515	2.80E-04	9935	2.35E-03
52.52	5.94E-03	16.40	1.85E-03	1.08	2.80E-04	17.48	1.98E-03	17098	3.67E-03	8629	1.85E-03	567	2.80E-04	9197	1.98E-03
57.26	5.89E-03	16.55	1.70E-03	1.19	2.80E-04	17.74	1.82E-03	18677	3.65E-03	8712	1.70E-03	624	2.80E-04	9336	1.82E-03
67.12	5.79E-03	15.47	1.34E-03	1.41	2.80E-04	16.88	1.46E-03	21971	3.60E-03	8142	1.34E-03	743	2.80E-04	8885	1.46E-03
77.50	5.71E-03	13.85	1.02E-03	1.65	2.80E-04	15.50	1.14E-03	25452	3.56E-03	7287	1.02E-03	871	2.80E-04	8158	1.14E-03
88.75	5.63E-03	12.33	7.83E-04	1.92	2.80E-04	14.25	9.04E-04	29235	3.53E-03	6489	7.83E-04	1011	2.80E-04	7500	9.04E-04
100.69	5.56E-03	10.11	5.58E-04	2.21	2.80E-04	12.31	6.80E-04	33260	3.49E-03	5318	5.58E-04	1161	2.80E-04	6479	6.80E-04
113.10	5.50E-03	7.40	3.60E-04	2.51	2.80E-04	9.90	4.82E-04	37453	3.46E-03	3892	3.60E-04	1319	2.80E-04	5211	4.82E-04
126.39	5.44E-03	5.78	2.49E-04	2.83	2.80E-04	8.61	3.71E-04	41954	3.43E-03	3043	2.49E-04	1490	2.80E-04	4533	3.71E-04
140.35	5.38E-03	3.48	1.33E-04	3.18	2.80E-04	6.65	2.55E-04	46691	3.40E-03	1830	1.33E-04	1672	2.80E-04	3502	2.55E-04
154.85	5.33E-03	2.62	9.01E-05	3.54	2.80E-04	6.15	2.12E-04	51622	3.38E-03	1377	9.01E-05	1862	2.80E-04	3239	2.12E-04
169.99	5.29E-03	0.09	2.69E-06	3.92	2.80E-04	4.01	1.25E-04	56783	3.36E-03	46	2.69E-06	2062	2.80E-04	2108	1.25E-04

Table 14. Modified Hughes resistance calculations for a sectionalized hull analysis of the SLICE.

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